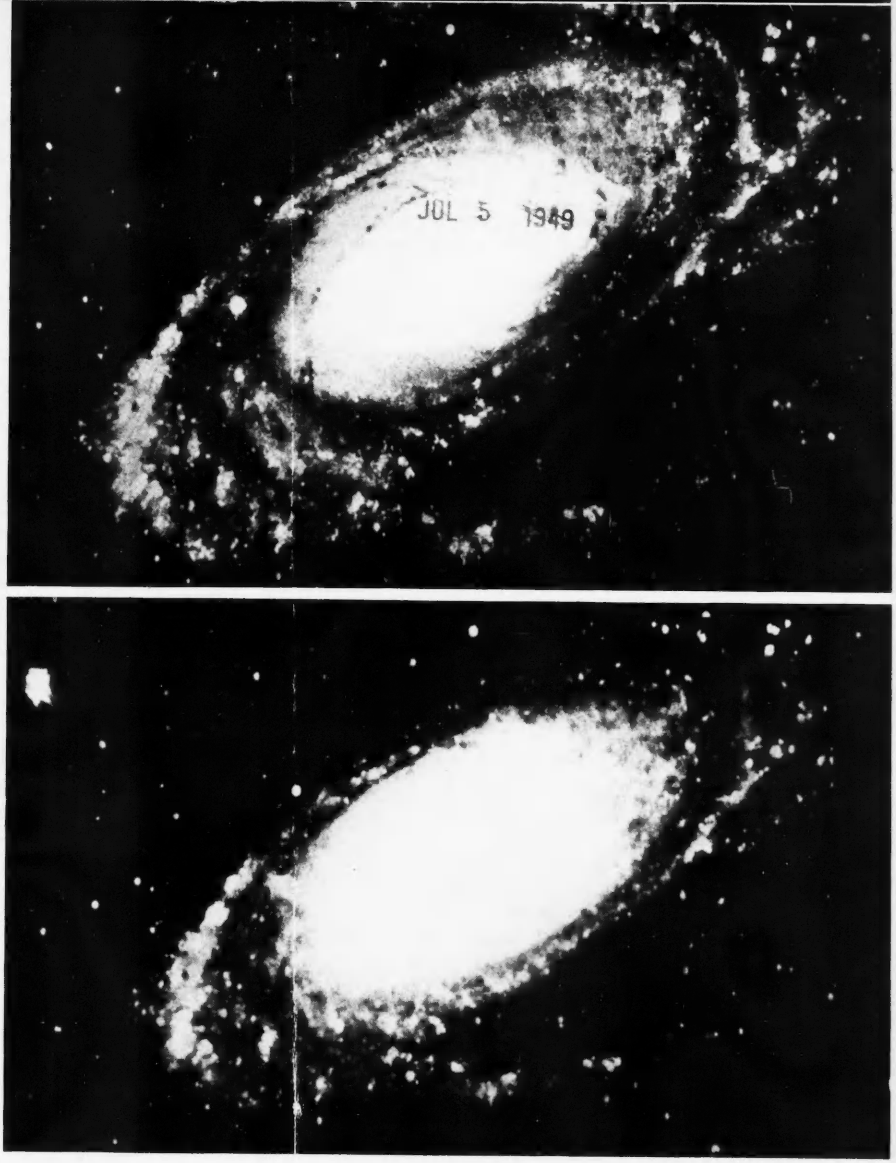
DISCOVERY



One of the first photos taken with the Palomar telescope (top) contrasted with a Mount Wilson photograph (See "Far and Near").

JUNE

1949

1/6

DISCOVERY

THE MAGAZINE OF SCIENTIFIC PROGRESS

June, 1949 Vol. X. No. 6

Editor WILLIAM E. DICK, B.Sc., F.L.S.
Editorial Office: 244 High Holborn, W.C.1. Tel. Chancery 6518
Advertisement Office: 161 Cheapside, E.C.2. Tel. Met. 9729
All Subscriptions, Distribution and Business Communications to Jarrold & Sons Ltd., Norwich. Tel. Norwich 25261

The Progress of Science

New Antibiotics

RECOGNITION of the remarkable therapeutic value of penicillin not unnaturally encouraged the belief that among the substances produced by moulds, bacteria, and other simple forms of life there would be others equally effective in attacking the different kinds of infection which assail the human body. As a result there began a world-wide programme of research in this field, and during the past few years thousands of different moulds and other simple organisms have been grown and studied with this object in view. The high hopes originally held have, however, been disappointed. Despite the intensity of the effort and the enthusiasm with which it has been made, immediate practical results have not been impressive, though it should not be forgotten that as an incidental result a wealth of potentially useful new information has been gained. Many new antibiotics have been isolated and closely investigated, but despite this penicillin remains in a class quite by itself.

The only other antibiotic which has proved of sufficient promise to justify large-scale industrial production is streptomycin, and even this has not proved wholly satisfactory and its real therapeutic value is not yet certain.

Quite recently, when the many research workers in this field might have been forgiven if they had begun to lose heart, two new antibiotics—chloromycetin and aureomycin—have been discovered which have already shown exceptional promise in clinical trials. A third—neomycin—has passed preliminary tests satisfactorily. These long-awaited successes will doubtless stimulate further research in this field.

Before describing these new substances it would perhaps be as well to point out very briefly why penicillin alone is not enough and why there is such urgent need to extend our armoury of antibacterial drugs. In a sense penicillin is an ideal drug. It is extremely deadly to bacteria and at the same time virtually harmless to the human body. Yet for all this it has definite limitations. A number of dangerous bacteria are either insensitive to penicillin or so little affected by it that it cannot be relied upon to destroy them once they have secured a firm hold on the body. Among these may be mentioned the deadly tubercle bacillus. Even among the many types of bacteria which are normally highly sensitive to penicillin there are liable to be odd strains which are resistant to it. Furthermore, it is possible for certain infections to become resistant to penicillin during the course of treatment, so that the drug becomes ineffective. Another point, though a relatively unimportant one, is that a few people have been found to be hypersensitive to penicillin, so that treatment with the drug results in the appearance of violent symptoms.

It is for such reasons as these that such importance has been attached to streptomycin—and particularly because this substance promises to be useful in attacking tuberculosis—but even penicillin and streptomycin together are far from covering the whole spectrum of bacterial infection and there is need for other drugs to fill the gaps.

Chloromycetin is doubly interesting. Not only is it most successful in attacking such serious infections as typhoid, typhus, and scrub typhus, but also it has been prepared synthetically. Rocky Mountain fever, a disease unfamiliar in this country, but a considerable problem in certain parts of the United States, is also cured by chloromycetin.

The story of chloromycetin began in 1947 when research workers at Yale University isolated a mould-like organism, known as an actinomycete, from a sample of soil sent to them from Venezuela. The actinomycete was found to produce an antibacterial substance and the nature of this was shortly afterwards investigated by chemists of Parke, Davis and Company of Detroit. From the metabolic products of the organism was isolated a crystalline antibiotic to which the name Chloromycetin was given. During the last few weeks the molecular architecture of chloromycetin has been worked out and a synthetic material, identical in every respect with the natural product, has been made in the Parke, Davis laboratories. The systematic chemical name is (1)-ψ-1-*p*-nitrophenyl-2-dichloroacetamido-propane-1 : 3-diol. To the trained organic chemist this name conveys two points of particular interest. One is the presence of a chlorine atom in the molecule, which is not particularly common in natural substances, and one is the presence of a nitro (nitrogen plus oxygen) group which is very rare in nature.

Chloromycetin had its first trials in Mexico in January 1948 when, given by mouth, it was used successfully to treat a few cases of louse-borne typhus. Its first really

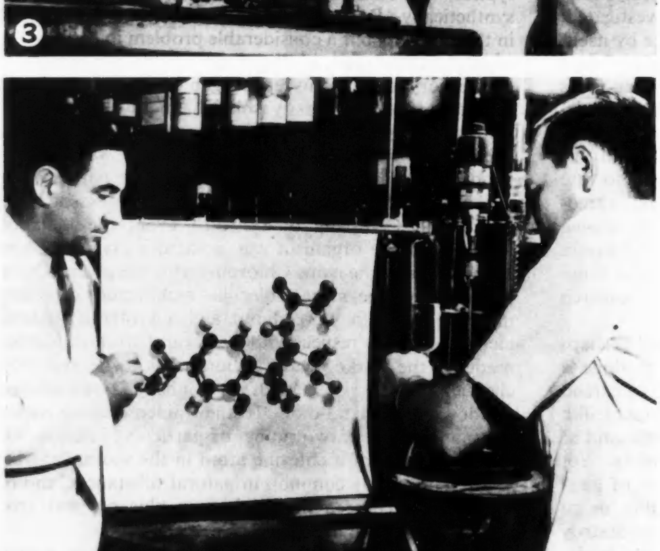
AN ANTIBIOTIC IS SYNTHESISED

The most encouraging advance to be made on the antibiotic front for a long time is the synthesis of Chloromycetin.

1. Chloromycetin was first produced by growing a soil mould in a liquid culture medium. This phase of the work was carried out by Dr. John Ehrlich, an American microbiologist who obtained enough of the drug for it to be tested on experimental animals.

2. Next step was the isolation of pure crystals of the antibiotic by Dr. Quentin R. Burtz.

3. After the chemical constitution of the drug had been established by microchemical methods of analysis, the attempt was made by a team of three workers to synthesise Chloromycetin in the laboratory. One of the team was Dr. Mildred Rebstock, here seen determining the melting-point of the antibiotic. The synthetic product they obtained proved to be identical with the natural drug; it showed the same activity against disease-organisms.



4. The synthetic technique was developed to the stage of commercial production by Dr. L. M. Long and H. Troutman, here seen looking at a model of the molecule of Chloromycetin.

large test, l
later, as a re
of the Insti
and a U.S.
This unit br
—all that w
The object
serious dise
in Malaya a
casualties ar
theatre of
spectacularl
no toxic syn
infallible in
characterist
it has justif
volunteers t
closely the r

Very rec
mycetin—to
given—has l
fully used t
scrub typhu

Typhoid
liminary rep
for treating
urinary infec

It is not ye
compares w
good reason
chemistry po
of this valua

Aureomyc
of an actino
particular sp
the name.
crystals. It s
new chemot
the human l
a wide range
do not respo
Particularly
Mountain fe
disease whic
United State
intermediate
mycetin has
aureomycin
and other sy
miraculous s

Another d
(which is so r
It is spread t
common on
States. Alth
exceedingly u
they include
Aureomycin
and disappea
in 48 hours.
aureomycin

A striking
aureomycin,

large test, however, came in Malaya some three months later, as a result of collaboration between the resident staff of the Institute for Medical Research at Kuala Lumpur and a U.S. Army medical research unit led by Dr. Smadel. This unit brought with them one pound of chloromycetin —all that was at that time available in the whole world. The object was to test the drug against scrub typhus, a serious disease, with a 10% death-rate, which is endemic in Malaya and adjacent territories and caused over 25,000 casualties among British and American troops in the Pacific theatre of war. From the very beginning results were spectacularly successful. Chloromycetin produces little or no toxic symptoms in the patients and so far has proved infallible in rapidly relieving the fever and other symptoms characteristic of scrub typhus. Indeed, it is so reliable that it has justified the risk of deliberately exposing human volunteers to infection as a means of investigating more closely the nature of the disease and the way it spreads.

Very recently a small quantity of synthetic chloromycetin—to which the name Chloramphenicol has been given—has been flown out to Kuala Lumpur and successfully used to treat two Gurkha soldiers suffering from scrub typhus.

Typhoid fever also yields to chloromycetin, and preliminary reports say that it is very likely to be useful also for treating certain types of pneumonia, whooping cough, urinary infections, and bacillary dysentery.

It is not yet known how the cost of the synthetic material compares with that produced by the mould, but there is good reason to hope that this new triumph of organic chemistry points the way to a cheap and plentiful supply of this valuable new drug.

Aureomycin, like chloromycetin, is a metabolic product of an actinomycete obtained from a sample of soil. The particular species is *Streptomyces aureofaciens*, and hence the name. The pure drug consists of fine golden-yellow crystals. It satisfies the first requirement essential for any new chemotherapeutic agent—that of being harmless to the human body. It is, at the same time, very deadly to a wide range of infective organisms, including many which do not respond to penicillin or streptomycin treatment. Particularly spectacular are the results of treating Rocky Mountain fever with aureomycin. This is a tick-borne disease which in recent years has spread throughout the United States. The causative organism is a rickettsia, intermediate in size between viruses and bacteria. Chloromycetin has been successfully used for treating it, but aureomycin appears to be even more specific. The fever and other symptoms of the disease disappear with almost miraculous speed.

Another disease which is caused by a rickettsia is Q-fever (which is so named because it first appeared in Queensland). It is spread through the agency of cows' milk and is now common on the west coasts of Canada and the United States. Although not very dangerous the symptoms are exceedingly unpleasant and normally last for 8 to 15 days; they include nausea, high fever, and severe muscular pain. Aureomycin results in a marked improvement in 24 hours and disappearance of the fever and recovery of appetite in 48 hours. Malignant brucellosis also has yielded to aureomycin when other drugs failed.

A striking feature common to both chloromycetin and aureomycin, but probably more marked in the latter, is that they will overcome certain infections caused not by bacteria but by the very much smaller, sub-microscopic, organisms known as viruses. Both chloromycetin and aureomycin, for example, will cure a type of pneumonia caused by virus infection. Aureomycin has been successfully used in the treatment of lymphogranuloma venereum, another very serious virus disease. The particular interest of these results is that, in general, substances which are active against bacteria do not attack viruses—indeed our weapons against virus diseases are at present very weak indeed. The success of antibiotics in this new field points the way to new triumphs among which it is not too optimistic to hope that the conquest of infantile paralysis will be included.

The study of the third of the new antibiotics, neomycin, is not nearly so far advanced as that of the two discussed above. Nevertheless, Professor S. A. Waksman, who discovered it, and who was also the discoverer of streptomycin, has expressed high hopes that it will prove useful in medicine and is carrying out a detailed study of all its properties. Neomycin, too, is produced by a soil organism, *Streptomyces fradiae*. It is a stable substance, easily soluble in water, which attacks a variety of infections, including tuberculosis and some which resist streptomycin. For example, in experiments with mice 100% cures have been obtained in infections which showed not the slightest response to streptomycin. It appears that infections show little tendency to become resistant to neomycin and the drug has such low toxicity that there should be little obstacle to its widespread use. Nevertheless, the claims so far made must be regarded as tentative, and it will probably be some months before the real value of this new antibiotic can be assessed.

Cybernetics

How do we recognise a square as a square, when actually our senses present it to us in a wide variety of different forms—large or small, far or near, really looking like a square when it is perpendicular to the line of sight, or tilted in various ways so that it looks rectangular or 'diamond-shaped'? That is one of the fundamental problems of psychology on which so far only very moderate progress has been made. An interesting clue to a *possible* answer cropped up in 1947 as a result of work which Dr. Warren McCulloch of Illinois was doing towards designing a machine to enable the blind to read print. The basic idea is that a line of print should be scanned by three photo-cells, one reading the top of the letters, one the middle, and one the bottom. Each cell while it is registering black will cause a musical tone to sound—a high-pitched tone for the top cell, a medium tone for the middle cell, and a low one for the bottom. Thus a *Z* would come out as two sustained notes at the top and bottom pitches with a short pip in the middle of them from the medium pitch; an *O* would give a pip at medium pitch, then two simultaneous pips high and low, and then another medium pip. The biggest difficulty is to allow for variations in the size of the type face. Dr. McCulloch sketched an apparatus to do this and set out its principle in the diagram reproduced as Fig. 1.

A neurophysiologist, Dr. von Bonin, happened to see this picture and immediately exclaimed, "Is this a diagram

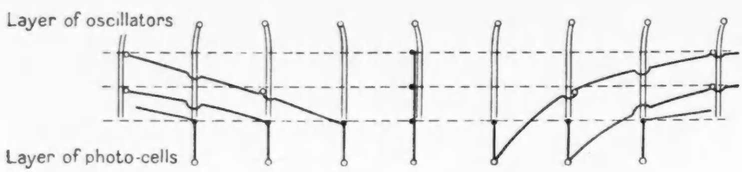


FIG. 1.—'Flow sheet' for an apparatus to allow the blind to read different sizes of print. The lowest line of circles represents a row of photo-cells which scan the print—those on the right scan the upper part, those on the left the lower. The circles in the top row represent oscillators for producing musical tones when stimulated by the photo-cells through various connexions; those on the right produce high tones; on the left, low. The single lines are leads from the photo-cells; the double lines, leads to the oscillators. Circles on the dotted lines are connexions between the two sets of leads; and the dotted lines represent a switching mechanism by which one set or other of the connexions is put into action. Thus if the print is small, only the middle three photo-cells are used; the connexions are those indicated by the top dotted line, giving a suitable spread of musical tones corresponding to the different parts of the printed line. For a larger type face, the middle five photo-cells come into action, and the connexions indicated by the middle dotted line are used. And similarly for still larger type, when all the cells are in action and the lowest set of connexions operate. The choice of connexions was originally intended to be done by hand.

of the fourth layer of the visual cortex of the brain?" The various connections bore a striking resemblance to the arrangements of neurons (nerve cells) in that part of the brain. This suggested that the means by which we recognise the similarity between objects of different sizes may bear some analogy to Dr. McCulloch's apparatus. Probably the brain mechanism would work on a scanning principle. It would try the connexions of each dotted line in turn, repeating the process endlessly. Another mechanism would compare the various output patterns with patterns stored in the memory, and when one of the former coincided (within certain tolerances) with one of the latter, it would send out a signal saying "Yes, this is a square."

Of course, this mechanism would deal only with size adjustment, which is merely one small part of the problem of recognising a square. But the principle can be extended. Consider the case of identifying an object viewed in perspective from different angles. Given its appearance from one angle, we can easily write out a set of mathematical formulae which would give all the ways in which it would look viewed from all possible angles. We can furthermore pick a representative set of these which can be scanned in much the same way as a television camera scans a representative set of spots on a picture. And we could design a machine on the lines of modern highly automatic calculating machines, which would take the given visual image (or rather some pattern of electrical pulses representing it); apply in turn each one of the transformations of the scanning set—that is to say, produce a series of new pulse patterns which would represent how the object *would* look from a representative selection of other angles; compare each one of these in turn with the various patterns stored up in the memory; and finally, when it came across a pattern that was identical with one in the memory, would send out a signal saying that it had recognised a square looked at from such and such an angle. An electronic machine could be designed to do all this; and so it is a reasonable tentative hypothesis that the corresponding parts of the brain may function in a similar way, with neurons and their connexions taking the place of the electrical and electronic elements of the machine.

Ideas about the functioning of the brain and nerves derived from such arguments must, of course, be speculative until and unless they can be verified directly by observing the actual way in which messages are passed round and transformed in the brain. But if history is any guide, such speculations should prove profitable. Physiology took its first serious steps forward when a series of workers, beginning with Leonardo da Vinci, and continuing through Harvey to Borelli, started to explore it in terms of analogies suggested by the new mechanics of the sixteenth and seventeenth centuries. It made another 'quantum jump' when the eighteenth-century chemical revolution suggested analogies that enabled the nature of respiration, for example, to be elucidated. In the late nineteenth-century the application of concepts derived from thermo-dynamics and the treatment of the body as a heat engine brought further great physiological advances. If the seventeenth century was the age of mechanics and the nineteenth was the age of the heat engine, then our own time is the age of electronics and particularly of electronic control and communication. And it ought to be possible to make another major advance in our knowledge of control and communications inside the body by using analogies derived from the highly complex control and communication systems that electronics has provided.

Modern highly automatic calculating machines have been nicknamed 'electronic brains'. This is obviously a misnomer, since there are very substantial differences between these machines and a brain. But there is enough resemblance to make it worthwhile to investigate whether any particular function of the brain is carried out by a mechanism similar to that of some analogous part of the machine.

For example, the central item of any of these machines is its memory—its ability to store patterns of information and yield them up again when an appropriate signal calls for them. And memory is also central to all human thought. In the machines there are usually two sorts of memory. There is a short-term memory which works by the process of keeping some pattern of pulses circulating continually round and round a circuit until it is wanted. (One way of doing this was described in DISCOVERY, February 1948, p. 40.) And there is a more long-term type of memory in which some part of the machine is altered in a permanent or semi-permanent manner—by punching holes in cards, varying the magnetisation of a magnetic tape, recording a pattern photographically, etc. There is some evidence that human memory involves these two different types also. When we multiply 39 by 3, we first multiply 9 by 3 to get 27. We put the 2 into a short-term memory device of some sort. We write down the 7, multiply 3 by 3 to get 9, extract the 2 from memory, add it to the 9 and so on (and anybody who cares to consider it in more detail

will find that many other acts of memory are involved even in this simple bit of thinking). Apparently the 2 which was memorised is cleared completely from the memory after use in much the same way as the contents of a calculating machine's short-term memory are cleared away when they are done with. And it seems not unlikely that the mechanism of this short-term human memory is analogous to that used by the machine —that some more or less complicated circuit of nerve connexions is set up and a series of signals representing the number 2 is kept circulating round until it is wanted again, and is then cleared away.

On the other hand, there is the sort of memory by which we recall the good time we had at Blackpool in the summer of 1923, and what Aunt Jane said when she lost her hat on the scenic railway. Such memories seem to be permanently recorded in the brain. The findings of psycho-analysis would suggest that they are never deleted—if we seem to forget it is only that we lose (or refuse to use) the power of calling the memories out of the store. Now the machine's long-term memories are also of this unforgettable type—provided we think only of a single run of the machine, which seems to be the best analogy for the life of a human being, since the cleared machine starting a new run is like a newly born human being, at least so far as memory is concerned. Can it be, then, that human long-term memory depends on irreversible alterations in the structure of the brain? There is some evidence that it depends in fact on changes in the amount of stimulation that a nerve cell must receive from others connected with it before it will act. And the evidence on the whole suggests that the changes are always in the direction of making the nerves less responsive to stimuli, and are never reversed. If this is so, each of us has only a finite capacity for long-term memory. When that capacity is near exhaustion it becomes difficult to accommodate new memories, though the old still remain. And so we get a plausible explanation for the fact that old people often find it difficult to remember what happened yesterday while they can recall vividly the events of their childhood.

These suggestions form a tiny fraction of the interesting speculations in a book called *Cybernetics** by Prof. Norbert Wiener (John Wiley, New York, 1948; Chapman and Hall, London, pp. 194, 18*s*.), which attempts to bring together the various aspects of control and communication problems that occur in many fields, ranging from steam-engine governors to the control of the hand in picking up a cigarette, and from telegraph messages through calculating machines and the human brain to the exchange of news and opinion in a social community.

* The term 'Cybernetics' is derived from the Greek word meaning *steersman*.

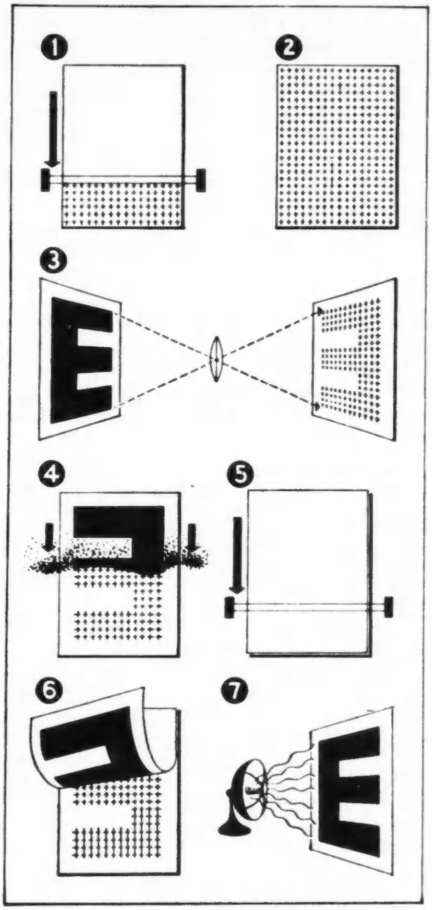


Figure 2.

1. Specially coated plate is electrically charged when it passes under wires.
2. Plate is coated with positive electricity

3. Projected image (E) is passed through lens and remains as positive charged image on plate. Charges disappear in areas exposed to light.

4. Negatively - charged powder adheres to positively-charged areas.
5. Paper placed over plate is given a positive charge.

6. Direct positive image is formed on paper as positive charge attracts powder.
7. Print is heated, fusing powder and forming permanent image.

A Dry Printing Process

A PHOTOGRAPHIC printing process has recently been invented which avoids all chemical manipulation. It makes use of the fact that certain materials—'photoconductive' materials—have the property of being electrical insulators in the dark but of becoming conductors after exposure to the light. The plate used consists of a conductive backing coated with a photoconductive layer (see Fig. 2). This is given an electric charge—by spraying it with electrons in a suitable device, or even by merely rubbing it with a cloth. The image which is to be reproduced is then projected on it by a lens (as in a camera or an enlarger). Where the light falls on the plate, the sensitive layer becomes a conductor, and so the charge leaks away. Where no light acts, the charge remains intact, so that at this stage there is a latent electrical image on the plate. To make it visible the plate is cascaded with a suitable powder containing fine resinous particles in a coarser carrier. The powder sticks to the charged parts, but rolls off those from which the charge has gone. This gives a positive image, though reversed, and really corresponds to the negative stage in ordinary silver-emulsion photography.

Printing is done as follows. A plate is prepared in the same way as above, except that the last stage of applying the powder is omitted. The plate is then fixed to the rotating cylinder of a printing machine, and as it rotates it goes through the following stages. First it passes under a corona discharge, which charges the plate all over. But those parts which were exposed to light are conducting, so that the charge here leaks away and only remains on the unexposed parts. As the cylinder turns farther the plate enters a 'developing chamber' and is there cascaded with powder, which adheres only to the charged (i.e. unexposed) areas. Paper, which is also given an electric charge, is now brought into contact with the plate as in ordinary printing. The charge on the paper attracts the powder image, which is therefore transferred to it. The plate is recharged and the cycle repeated. The paper passes on to a heating unit where the powder image is fixed by heat.

According to *Electrical Engineering* for January 1949, from which Fig. 2 was taken, "the process is dry, fast, simple, and cheap," and "is expected to make radical changes in the publishing and printing fields".

A Flying Laboratory

In testing a modern aircraft nothing is left to chance. The days when a test pilot just took a new machine into the air and made a few rough notes on a pad strapped to his knee are over. Everything is done scientifically nowadays; particularly is this so in the case of an aeroplane of the size of the Bristol Brabazon I, the 130-ton giant which is the biggest aeroplane ever built in this country.

Ground and air tests of the Brabazon will go on for many months; the prototype which, with the vast assembly hangar and the great runway at Filton, has cost about £12,000,000, was never intended to be anything but an experimental aeroplane. It will never be operated commercially. So the inside of the great fuselage has been fitted out as an aerial laboratory—and not with comfortable passenger lounges.

Filming a Thousand Instrument Dials

Every hour of testing the Brabazon, whether on the ground or when test pilot Arthur John Pegg takes her into the air, will be put on the record in a scientific manner. To do this 1000 instrument dials and oscillographs have been fitted in the aeroplane. These will tell the test engineers and the Bristol design team under Mr. A. E. Russell, the chief designer, all they want to know about the Brabazon and its behaviour and performance.

The test instruments will also give the designers a great deal of information which, it is hoped, will help to speed up production of the Mark II Brabazon. Though a start has been made on construction of the second model, it is only a few ribs so far. Obviously it is no good going too far with the construction of the Mark II until the designers have a good deal of data from the Mark I.

Every part of the Brabazon will be tested, and as it taxies along the Filton runway or flies on short or long journeys, a record of the readings on the 1000 dials will be made for the testers by special cameras.

Afterwards these films will be analysed in the Bristol Aeroplane Company's Flight Research Laboratory.

In order that each group of dials shall tell the story of some aspect of performance without the need for cross reference, the instrument dials are grouped in 12 panels. These 12 panels will show:

1. The performance of the aeroplane itself; speed, altitude, rate of climb, etc.
2. Performance of the hydraulic system and the electrical system.
3. The operation of the power-operated hydraulic controls.
4. Engine cooling.
5. Engine temperature.
6. Engine oil temperature.
7. How the propellers are working.
8. Oil temperature in the hydraulic system.
9. Output of the electrical generating plant.
10. The pressurisation apparatus.
11. The de-icing equipment, including the temperatures on the external 'skin' of the aeroplane, and
12. Aerodynamic pressures and flows.

Each group has its own camera, and all 12 cameras are controlled from a master station on the flight deck where the Chief Test Engineer will be stationed during the ground and air tests. The testers watching the dials can, however, override the master control if they notice anything they think should be photographed.

Under normal test conditions all the cameras will take photographs at the same instant so as to obtain a complete record of all performances at a given moment. Two types of camera are used. Some of the dials are being photographed on negatives 5 in. by 5 in.—large enough to accommodate 170 dials—at rates varying from one exposure every ten minutes to one every other second. Other dials, the ones that change more rapidly, are being photographed by 35 mm. cine-cameras, possibly at as high a rate as four pictures a second. This small film can record over 60 dials at a time.

Recording Vibrations

Low-frequency vibrations of up to 60 cycles per second, like those caused by aerodynamic forces and steady strains in the structure, are being recorded on two mirror galvanometer oscillographs, each able to record 15 quantities simultaneously.

High-frequency vibrations, up to 1000 cycles per second—such as those caused by the eight engines—are being recorded by cathode-ray oscillographs which can handle four measuring points at a time.

Additionally three lamp recorders, each containing 120 lamps will during the tests carry out a continuous watch on the operation of various emergency devices in the Brabazon. When any one of the lamps lights up it produces a line on a slowly moving film and records precisely the timing and duration of the operation.

The test engineers are also to have several portable self recording instruments, and, say Bristol scientists, these in conjunction with two double beam cathode-ray oscillographs will enable any flight phenomena to be watched.

It is expected that the task of interpreting all the mass of data gathered by the test engineers will take 100 hours of laboratory work for every hour of testing the Brabazon. But all these test records will be of great value, not only for the building of further Brabazons, but for the future of aircraft design. Certainly it looks as if the tests of the Brabazon will be the most comprehensive ever undertaken on a new aircraft in this country.

J. S.

Sweeter than Sugar

NEW SYNTHETIC COMPOUNDS MORE POTENT THAN SACCHARIN

FREDERICK KURZER, Ph.D., A.R.I.C.

SUGAR, one of the most important products derived from natural sources, is of exceptional interest because of its value as a foodstuff—the figure for the annual sugar production runs into millions of tons—and because of its sweet taste. Apart from the nutritional importance, the taste of sugar and of related substances is of particular significance, and has repeatedly attracted the attention of physiologists and chemists.

It is well known that the large variety of 'tastes' commonly experienced are not due to our taste-sense alone but are a combination of the additional sensations of temperature, touch, and especially smell. Our inability to taste food when suffering from a cold is familiar to everyone. The dependence of our discrimination on the sense of smell can be strikingly shown by tasting a few dishes while our nasal passage is closed: the palate, wrongly credited with our power to recognise and appreciate flavours, fails to distinguish between boiled potatoes, turnips, and even onions; different meats taste alike, and a varying degree of sweetness is all that remains of various fruit flavours. On the other hand, some substances with apparently strong scents are in fact perceived by our taste rather than smell. The sweetish odour of chloroform, for example, is detected by the taste-buds in the mouth.

It is remarkable how clearly the complex nature of taste was realised by Francis Bacon, and the lucid observations in his *Novum Organum* (1620) appear to be worth quoting in full: "Those who do not smell, but are deprived by nature of that sense do not perceive or distinguish rancid or putrid food by their taste, nor garlic from roses and the like. Again, those whose nostrils are obstructed by accident (such as a cold), do not distinguish any putrid or rancid matter from anything sprinkled with rose water. If those who suffer from a cold, blow their noses violently at the moment in which they have anything fetid or perfumed in their mouth, or on their palate, they instantly have a clear perception of the fetor or perfume. These instances afford the division of taste, namely, that it is in part nothing but an internal smelling, passing and descending through the upper passages of the nostrils to the mouth and palate. But, on the other hand, those whose power of smelling is deficient or obstructed, perceive what is salt, sweet, pungent, acid, rough and bitter and the like as well as anyone else; so that the taste is clearly something compounded of the internal smelling and an exquisite species of touch."

It is now generally agreed that there are four primary tastes which can be distinguished independently of the other senses; they include the perception of sweet, sour, salty, and bitter stimuli. The taste-buds, which act as receptors of these sensations, are concentrated on minute projections, known as 'papillae', and the question whether specific papillae are responsible for the transmission of each primary taste has been investigated; it appears that they are not selective to one taste with the exclusion of all others, but show increased sensitivities according to their positions: thus, sweetness is most efficiently perceived at the tip of the tongue, the bitter taste towards the back, the sour at the sides, and the saline at and near the tip. As a rule, the sensation of taste occurs only when the papillae are excited by actual contact with the substance in question, preferably in aqueous solution.

The use of sugar or other materials for sweetening purposes is not as universal as is commonly supposed and seems to be associated with a human diet mainly made up of vegetable food; people subsisting on pure meat diets have apparently no craving for sweet flavours—polar tribes and nomadic populations in Northern Asia and Tibet, for example, who live almost entirely on meat, are not accustomed to the use of sugar. It is particularly interesting that African meat-eating tribes, who find no attraction in the sweet taste of honey, have recognised its value for purposes of barter with their vegetarian neighbours and collect wild honey with great zeal, though they eat none themselves.

Today the most important and valuable sweetening agent is undoubtedly sugar, which is obtained from the sugar cane and sugar beet. The former is generally believed to have originated in Northern India, from where it spread first into China and then to other countries. For many centuries, sugar was enjoyed by simply chewing the cane and drinking the juice; the earliest evidence of sugar in the solid form refers to its use about A.D. 500 in Persia; in the ancient Persian language white sugar was called 'kandi-sefid', from which the term 'candy' is derived.

Sugar manufacture and refining on a commercial scale developed during the ninth and tenth century in Egypt, and the export of this product became increasingly important. In medieval times, honey, in limited supply, was still the main sweetening agent in Europe. Sugar was a costly delicacy that only the nobility could afford; it was believed to possess miraculous healing powers, and was a favourite ingredient in medical prescriptions of that period. Sugar became more widely known after its introduction to France by returning crusaders in the eleventh century; its general use and commercial development in Europe dates from that time. Cane sugar was introduced to the Western hemisphere on Columbus' second voyage in 1494, and within a short time the production of raw sugar from cane grown in tropical America was one of the greatest industries in the world. Large-scale cane sugar refining, begun during the early part of the nineteenth century in England, was soon followed by the commercial exploitation of the sugar beet, whose early cultivation and improvement for sugar content was largely due to French initiative.

Synthetic Sweetening Agents

Sugar is the ideal sweetening agent not only because of its 'right' taste, free from any interfering flavours, but also

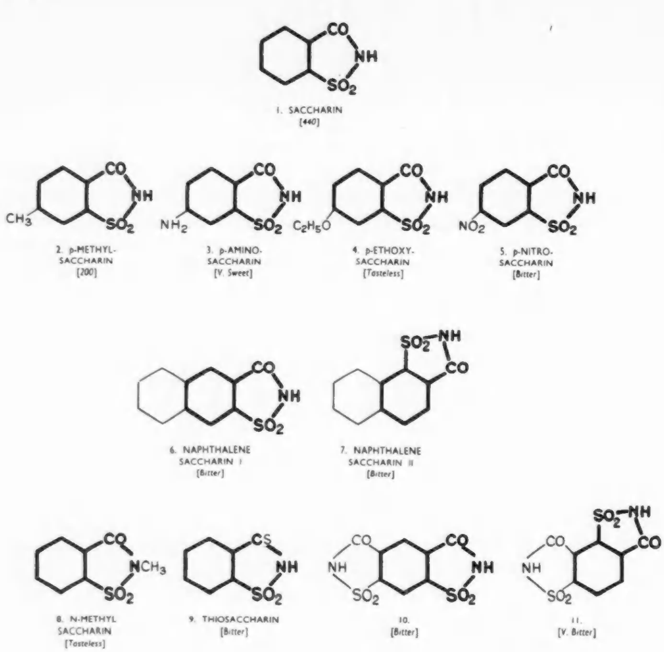


FIG. 1.—How sweetness changes as molecular structure is altered. The saccharin-prototype is shown in heavy print, with the various modifications in lighter type, indicating clearly how the saccharin pattern is retained in the whole series of compounds. Bracketed numbers refer to the degree of sweetness.

because of its high food value. Whether obtained from cane or beet, it is practically pure sucrose, $C_{12}H_{22}O_{11}$, a substance of the carbohydrate type, and as such one of the most valuable energy producers. Its importance to the active human body and to the growing organism is too well known to require further emphasis. When the consumption of sugar and other carbohydrates must be kept to a minimum (*e.g.* by persons suffering from diabetes) other substances having sweetening power can be used. During the world wars, when supplies of sugar became seriously limited, synthetic sweetening agents assumed greater significance than ever before. There exist, fortunately, a number of substances, first synthesised by the organic chemist in the laboratory and then produced on a factory scale, which are many times as sweet as sucrose and can be used to flavour a wide range of food products. They have no nutritive value and cannot, therefore, be termed 'sugar substitutes' but they do impart a satisfactory degree of sweetness that is almost free from undesirable flavours; they are quite harmless in the small concentrations required, and can be manufactured without undue difficulties from readily available raw materials.

The Discovery of Saccharin

Saccharin, the oldest and best known synthetic sweetening agent was discovered in 1879 by I. Remsen and C. Fahlberg. Remsen, then professor of chemistry at Johns Hopkins University, was busy with a comprehensive study of the oxidation of sulphonic acids, and was joined by a young postgraduate research worker, Fahlberg. The story is told that Fahlberg, arriving home for supper one evening, realised that the bread and all the other food he touched were unusually sweet. He traced the taste to his hands and, returning to the laboratory the same night, found that it was one of the oxidation products of the *ortho*-toluenesulphonamide he had been handling during the day that was the cause of that remarkable sweetness. On closer investigation the substance proved to be ortho-sulphobenzoic imide, which became later known commercially as 'saccharin'.

Because of the unexpected properties of this new substance an unfortunate controversy began as to who was its actual discoverer. Remsen, who was interested in the broader theoretical implications of his researches rather than in the preparation of new substances, probably took only a passing interest in the intense sweetness of saccharin; to him it was just another of a large number of new compounds that he had synthesised in the course of a much wider research programme. In a paper, published jointly with Fahlberg in the *American Chemical Journal*, Remsen dismissed the sweetness of ortho-sulphobenzoic imide, and its other properties, in a line or two. Fahlberg, however, immediately recognised the commercial possibilities of the discovery and filed a number of patents protecting the name "saccharin" at the same time. Remsen, as the senior worker and director of the investigation which had given these results, could have contested the validity of the patents, but declined to do so, saying that he 'would not soil his hands with industry'. It was only later, when Fahlberg began to claim the discovery entirely for himself, that Remsen was occasionally provoked to express his impatience in chemical journals, and give vent to even stronger feelings when writing to his close friends. Thus, a letter to Sir William Ramsay, with whom Remsen had studied in Germany, contains the following passage: "Some months ago there was published, by my friend Fahlberg, an article in which certain misrepresentations occurred. . . . In some way Fahlberg has succeeded in making prominent chemists in England believe that my part in the discovery of saccharin was a secondary one. This is not, to be sure, a very important matter, but it makes my blood boil to see the lies of that rascal in print and to see, further, that they are pretty generally believed. His recent paper directed against me contained two direct lies. Anyone who will take the trouble to look up the original papers can see for himself under what circumstances the investigation was taken up." Nevertheless, due credit must be given to Fahlberg for his skill and patience in working out a successful large-scale manufacturing process for the production of saccharin, though there is no doubt that had he freely admitted his teacher's part in the investigation, and shared, if not the proceeds, at least the honour of the discovery with him, an unfortunate and fruitless controversy would have been avoided.

Saccharin can now be manufactured in large quantities by several processes and forms a white crystalline powder, sparingly soluble in hot water (approximately 1 part of saccharin dissolves in 400 parts of water) and still less soluble in cold liquids. Its low solubility is compensated by its great sweetening power, so that very minute concentrations of saccharin confer a sufficient degree of sweetness on a food product. The average person is capable of recognising the presence of saccharin at a dilution of 1 part in 100,000 parts of water, whereas a concentration of 1 part of cane sugar in not more than 200 parts water is required before its taste becomes noticeable. The 'sweetening power' of saccharin is therefore said to be 400 times that of cane sugar.

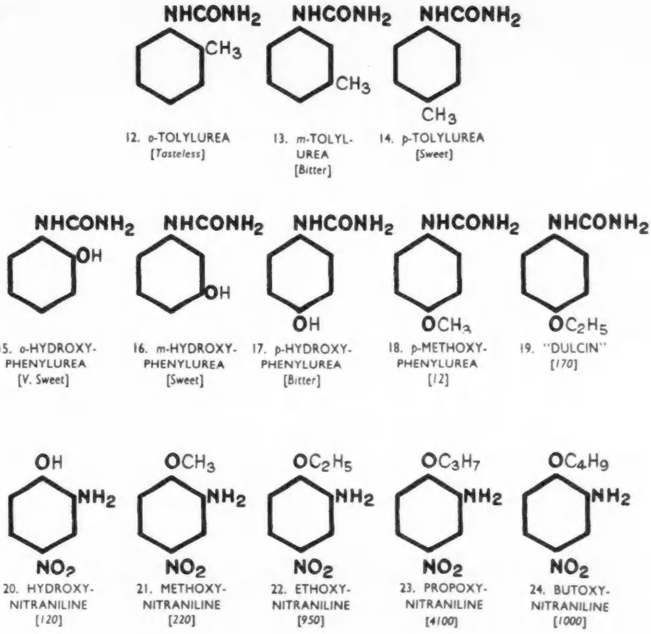


FIG. 2.—This diagram shows how, in another range of compounds, slight changes in the architecture of the molecule cause considerable changes in the taste. The bracketed numbers refer to the sweetening power of the different compounds. "Dulcin" (No. 19) is a commercial product; Compound No. 23 is the sweetest compound yet discovered.

Comparing Sweetness

Incidentally the intensity of the sweetness of a substance is not easy to determine in practice. It cannot be measured on an *absolute* scale; instead the taste of solutions containing a known amount of the substance must be compared with that of sugar solutions of known strength. Like every other human faculty, however, tasting ability is developed to a different degree in various individuals. The refinement of the taste sense varies not only with the age and sex of the observers—women are considered to have a better palate than men for bitter, sweet and sour substances, while men are more sensitive to salt stimuli—but also on individual personal differences, and a large number of observations by several persons is therefore required to arrive at a reasonably accurate result.

For the determination of sweetness, the 'threshold-concentration' method is most commonly used. As its name suggests, it involves the measurement of the lowest concentration of the substance which can just be tasted. A comparison of this figure with the threshold-concentration of sucrose gives the sweetening power of the material examined. Another procedure, in which a standard 2% solution of sucrose is used for reference, involves the preparation of two solutions of the substance under examination, one sweeter, and the other less sweet than the standard. A series of solutions of intermediate and known strengths between these limits are then made up and the one most closely approaching the sweetness of the 2% sucrose solution is found. This method has the advantage of affording a direct comparison of more concentrated solutions, but is apt to be at times less accurate since it necessitates 'remembering' degrees of sweetness during the test. As in all determinations of taste-intensity, a large number of tests, carried out by several observers, ensure more accurate results. In view of these and other difficulties it is not surprising that the sweetness of saccharin is variously given as 400–600 times that of pure cane sugar.

The sodium-salt of saccharin ('crystallose'), which is readily soluble in water, has similar sweetening properties. Owing to its very powerful taste it is often diluted by mixing it with less efficient sweeteners (*e.g.* glycerine) or neutral substances such as starch.

It has already been indicated that saccharin passes through the body unchanged and has no food value, and its use in place of sugar in the diet can only be approved as an emergency measure, or recommended in conditions when the consumption of carbohydrates is undesirable. Saccharin has frequently been attacked on the grounds that its prolonged consumption causes unfavourable and even serious effects, but such criticisms are, on the whole, unfounded. Many experiments by independent investigators have shown that even large doses of saccharin are quite non-poisonous. At the same time it would be wrong to assume that, except for its action on the taste organs in the mouth, saccharin is an inert substance. It possesses valuable antiseptic properties. On the other hand it has been reported to affect the appetite unfavourably and to decrease gastric secretion and absorption in the small intestine.

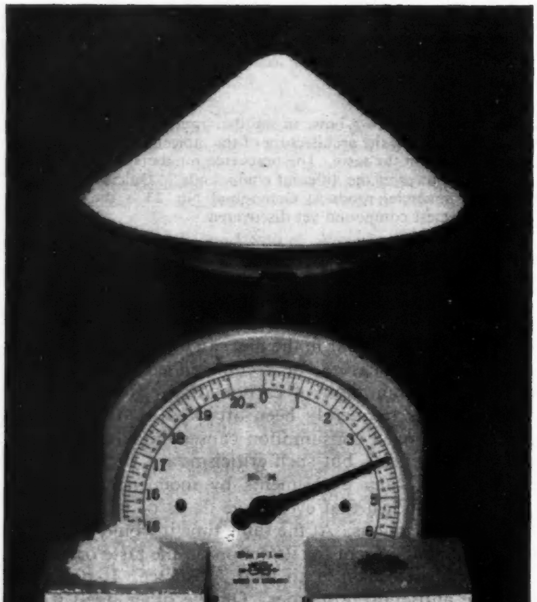
Dulcin

Dulcin (*p*-ethoxyphenylurea), first prepared in 1892, possesses a number of particularly desirable properties, which are responsible for its great importance as a synthetic sweetening agent. This product is approximately 200 times as sweet as sucrose, and sufficiently soluble for flavouring purposes. It has an agreeably pure taste, free from the metallic or 'chemical' after-taste sometimes

ascribed to saccharin, and has been found to be entirely harmless.

Although a number of other substances of intensely sweet taste have been described from time to time, they have almost invariably shown other properties that made their general use impossible, so that no new commercially important products appeared on the market for many years. In 1920, for example, Japanese workers pointed out that *perilla aldehyde antialdoxime*, obtainable from perilla oil (a material sometimes used in paints and varnishes), possessed a sweetening power 2000 times that of sugar; unfortunately the substance combined its strong taste with an even stronger odour, which appeared to make it suitable as a perfume rather than a sweetening agent. *Syn-5-benzyl-2-furfuraldoxime*, a compound with a more powerful taste than saccharin, was discovered by American chemists, but its pungent after-effect on the tongue again prevented its use in food manufacture.

More recently interest has been aroused by the results of investigations carried out in the University of Leyden and in industrial research laboratories in Holland. Certain derivatives of nitraniline (which is itself a common intermediate in the manufacture of aniline dyes) have often



This photograph demonstrates the intense sweetness of the synthetic sweetening agents. The small amount of saccharin on the left-hand stand and the even smaller quantity of propoxy-nitraniline are equivalent to the four pounds of sugar on the scale.

TABLE I

THE SWEETENING POWER OF SOME ORGANIC COMPOUNDS

Sucrose	1	
Dulcin	170	(70–350)
Saccharin	440	(200–700)
Perilla-anti-aldoxime	2000	
Hydroxy-nitraniline (1-hydroxy-2-amino-4-nitrobenzene)	120	
Methoxy-nitraniline	220	
Ethoxy-nitraniline	950	
Propoxy-nitraniline	4100	
Butoxy-nitraniline	1000	

been found to possess a pronounced sweet taste. Particularly encouraging results were obtained by the Dutch scientists with a number of new chemicals, in which the characteristics of phenols were incorporated in the *meta*-nitraniline 'pattern'. They synthesised a series of such compounds, whose molecules contained an increasing number of carbon and hydrogen atoms, and determined the degree of sweetness of each substance of this 'homologous series'.*

The Sweetest Compound Known

The fourth compound in their sequence, *propoxy-nitraniline*, was found to possess the most intense taste, having 4100 times the sweetening capacity of sugar, or 8–10 times that of saccharin; it is, to date, the sweetest substance known (see Table I). The product has been claimed to show all the properties of the ideal synthetic sweetening agent: it can be easily prepared in the pure state and is entirely non-poisonous; it does not decompose on heating or prolonged boiling in water or slightly acid media, and therefore can be used in the manufacture of beverages and such food products as custard powders, confectionery and jams. Propoxy-nitraniline consists of orange crystals which are only very slightly soluble. Although 1 litre of water takes up only 0·136 gram at ordinary temperature, the solution corresponds in taste to a syrup containing half its weight of sugar. The orange colour of the substance, which would at first sight appear to be a drawback, does not limit its practical application because of the small concentrations involved, and because the materials to be sweetened are usually coloured to start with.

A comprehensive study of the relationships between physiological activity and chemical structure has become one of the central problems of modern research, and has resulted in truly spectacular advances in several fields, particularly in chemotherapy. Attempts have frequently been made to trace a connexion between the taste of organic substances and the 'architecture' of their molecules. Taking some compound of known sweet taste as model, chemists prepared large numbers of substances differing in various ways from the prototype in the hope of discovering the arrangement of atoms that is responsible for the sweet taste. Although the large accumulation of data has

* A series of compounds each differing from the next in the series by a $-CH_2-$group.

resulted in our recognition of certain 'dulcigen' groups of atoms responsible for the property of sweetness, it seems to be generally true that sweetness is a highly specific property of the molecule *as a whole*, and is easily lost on the slightest variation in its structure. Since saccharin has been the outstanding sweetening agent for many years, chemists have been particularly interested in this molecular pattern and have prepared many compounds of the saccharin-type in the hope of finding alternative and possibly more powerful sweeteners. Their search has shown, however, that varying this structure is not only accompanied by a decrease in the sweetening power, but results more often in the complete destruction of the taste; indeed, many compounds resembling saccharin very closely in their structure turn out to be intensely bitter. The differing tastes of the variations on the saccharin molecule are given in Fig. 1. We see that the sweet taste is retained, though to a lesser degree, in *p-methyl-* (2) and *p-amino-saccharin* (3); it is lost in *p-ethoxy-saccharin* (4), while introduction of a nitro-group produces the very bitter *p-nitro-saccharin* (5). Owing to the well-known close relationship between benzene and naphthalene, it was to be expected that substances of type 6 and 7 ('*naphthalene-saccharins*') would show a pronounced taste; this was indeed the case, but investigators were disappointed to find that their newly synthesised compounds, so similar to saccharin, were intensely bitter.

The influence of isomerism* on the sweetening power is illustrated by certain urea derivatives shown in Fig. 2. Of the three *tolyl-ureas* (12–14), only the *para*-isomer (14) is sweet, while in the case of hydroxyphenyl-ureas the *ortho*-compound (15) shows the greatest degree of sweetness. The closely related members of a homologous series often exhibit a surprising variation in the intensity of their taste, which is quite unparalleled by the rest of their properties. Thus, in the *alkoxy-nitranilines* (20–24), the sweetening power rises increasingly rapidly from compound to compound to reach the maximum of 4100 units in *propoxy-nitraniline* (23), but falls off again as larger alkyl groups are introduced into the molecule. (See Table I and Fig. 2.) Similar observations are made with analogues of dulcin, where maximum sweetness occurs in dulcin itself (19).

The few examples that have been chosen could be multiplied almost indefinitely from the wealth of experimental work on record. They illustrate clearly, however, that sweet taste may be associated with compounds that are, chemically, quite unrelated (*e.g.* sucrose, saccharin, dulcin). Again, although two substances resembling one another closely in structure may also correspond in their taste, a sharp contrast in this property is by no means unusual. In spite of a rapidly increasing literature on the relationship between chemical constitution and physiological activity, and on the correlation of structure and taste, our knowledge is not sufficiently advanced to justify broad and inflexible generalisations. A better understanding of these relations will no doubt be gained by further researches, and new light may well be thrown on this problem, as has happened so often in the advance of science, by progress in other fields of inquiry.

* Substances having the same chemical composition but different properties are called *isomers*; the phenomenon is called *isomerism*. Isomerism may be due, as in the above case, to a different arrangement of the same atoms within the molecules.

READING LIST

(1) S. P. Scholz, *Synthetic Organic Compounds*, London, 1925.
(2) M. B. Jacobs, *Synthetic Food Adjuncts*, New York, 1947.
(3) R. W. Moncrieff, *The Chemical Senses*, London, 1944.
(4) F. H. Getman, *The Life of Ira Remsen*, Easton, Pa., 1940.
(5) P. E. Verkade, "A New Sweetening Material", *Food Manufacture*, 1946, **21**, 483.

A CHEAP RAT REPELLENT

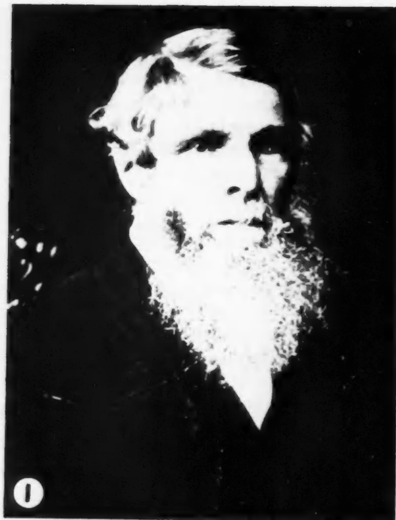
A rat-repelling chemical that promises to keep rodents out of cardboard packets and thus to end losses totalling many million pounds a year was described at a recent meeting of the American Chemical Society in Chicago. The compound is no newcomer on the chemical scene, but a cheap, well-known product already used for mothproofing and several other purposes, said Clifford A. Hampel of the Armour Research Foundation.

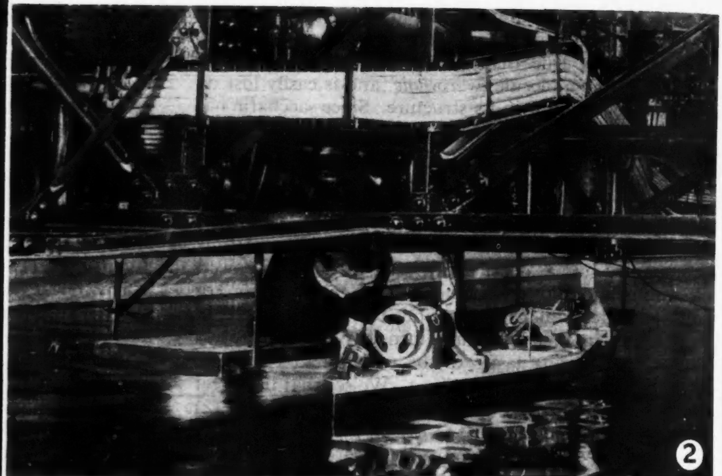
That the chemical, called sodium fluosilicate, may be the answer to industry's long search for an effective rat repellent was discovered in the course of a year's survey conducted by the Armour Foundation to find new uses for the compound, Mr. Hampel explained. The substance also proved to possess important potentialities as an insect repellent, particularly for termites and cockroaches; a mosquito control agent; and as a dry rot preventive for wood and other cellulose materials used in construction, he said.

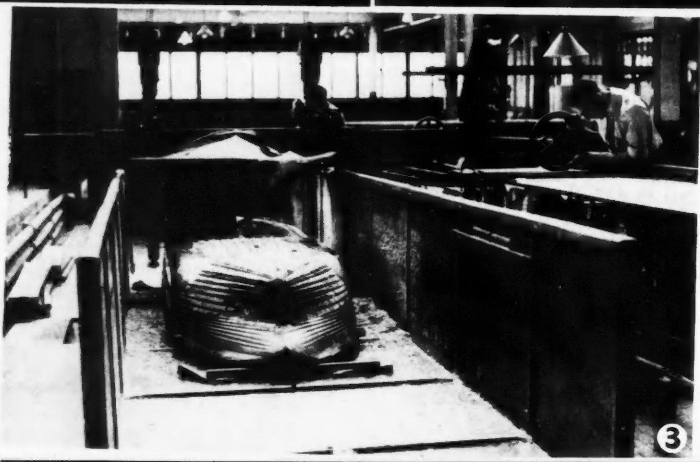
Although toxic, the compound apparently is of no value as a rodenticide, Mr. Hampel reported, as studies at the Patuxent Research Refuge of the United States Fish and Wild Life Service disclosed that rats will turn up their noses at food containing even a small amount of sodium fluosilicate. But this, of course, suggested the use of the chemical as a repellent, and as a result intensive tests are now under way to determine its effectiveness along this line when incorporated in paperboard cartons. Cockroaches also shy away from sodium fluosilicate unless it is disguised in a bait.

Sodium fluosilicate, which can be produced very cheaply, is extremely toxic to insects and other lower organisms, such as bacteria and fungi, but its value against insects on plants is slight because it forms acid solutions when mixed with water and thus causes leaf burning. It has long been used, however, as the chief ingredient in a popular mothproofing solution, and is particularly effective on woollen clothing, rugs, and upholstery.

Tests at the Armour Foundation and elsewhere have shown the chemical to be highly effective in combating dry rot fungi which causes annual damage running into millions in the construction field.





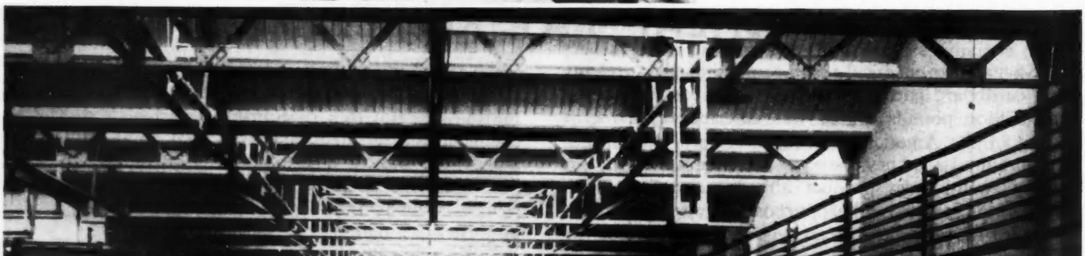


1. William Froude (1810-1879), who founded the methods of ship model research. (Photograph by courtesy of the Director of the Science Museum.)

2. A model in position under the carriage, about to be tested for screw efficiency.

3. A paraffin-wax model of a ship in process of construction.

4. The Yarrow Tank at the National Physical Laboratory, showing the travelling carriage that tows the model ships.



Shi

It is a meth
ship by car
years ago b
last eighty
essential to
advances in
There are n
six of them
say that no
trade or wa

Some of t
performanc
calculation.
that of resi
drive a shi
architect's c
derived fron
resistance b
full-scale sh

The prin
is towed in a
pull it exert
this resistan
still unsolve
used in 175
the results
because the
ship with it
they remain
the historia
similarity t
William Fro
on his fathe
in the many
a record in

For the p
resistance o
tance and v
the effect of
tions of the
turbance m
two resistan
come to atta
experiments
resistances a
ently. This
model expe
for the prob
components
laws—that
scale—so th
from the mo

Froude's
resistance v
varies as the
figures this
will have c
prototype.

Ship Design and Model Experiments

DOUGLAS H. C. BIRT, A.I.N.A.

It is a method of great antiquity to design the shape of a ship by carving a model. This method was replaced many years ago by the drawing board and pencil, but within the last eighty years models have again become one of the essential tools of naval architecture, and the greatest advances in design have been due to model experiments. There are now over fifty model-testing tanks in the world, six of them being in this country, and it is not too much to say that no nation can hope to compete upon the seas in trade or war without their constant assistance.

Some of the most important factors influencing a vessel's performance are not amenable to direct mathematical calculation. Amongst them, and of the first importance, is that of resistance. What power of engine is necessary to drive a ship at the specified speed? This is the naval architect's capital problem, and the solution to it must be derived from model tests, the measured value of the model's resistance being converted to the amount applicable to the full-scale ship.

The principle is simple. A model of a proposed ship is towed in a testing tank, and its resistance measured by the pull it exerts on the towing arm. It is in the extension of this resistance to the full-scale vessel that problems, some still unsolved, start arising. Though models were being used in 1750 for predicting the resistance of sailing ships, the results obtained were confusing rather than useful, because the necessary laws of comparison connecting a ship with its model, to any given scale, were lacking; and they remained unknown until William Froude, brother of the historian, applied Lord Rayleigh's law of dynamic similarity to ships. This was in 1871. The methods of William Froude, and of his son, R. E. Froude, who carried on his father's work, are in use today, and almost unaltered in the many years since their formulation; this perhaps is a record in longevity for a technical scientific process.

For the purposes of this study we may say that the total resistance of a ship has two components, frictional resistance and wave-making resistance. The former is simply the effect of the water rubbing along the submerged portions of the ship's hull; the second is due to the wave disturbance made by a ship's moving bulk. The sum of the two resistances is the force which the engines have to overcome to attain a given speed. The basic principle of model experiments, enunciated by Froude, is that the two resistances are separable and may be measured independently. This was the essential first step towards making model experiments capable of giving quantitative data, for the problem was complicated by the fact that the two components of the total resistance obey different physical laws—that is, they vary in different proportions with the scale—so that the correct scale speed for the measurement from the model of one resistance is not right for the other.

Froude's Law of Comparison states that the wave resistance varies as the cube of the scale when the speed varies as the square root of the length. Expressed in simple figures this means that a scale model one-tenth of full size will have one-thousandth of the wave resistance of its prototype. Again, keeping to simple figures, if a ship 100 ft. long is to have a speed of 10 knots, the resistance of such a ship at this speed may be found by running a 9-ft. model at 3 knots (this being the proportionate speed for the scale) and scaling up the measured resistance.

Now this law is true only for wave-making resistance, and it is to measure this quantity that elaborate and costly tank-testing laboratories have been established. Skin friction is a simpler matter; due to the Froudes it is mathematically calculable for both ship and model. It is, in fact, a very simple calculation, though its theoretical basis is now recognised as being something less than the whole truth. Wave-making resistance has defied mathematical analysis. Efforts are being made in many lands to reduce this matter to a mathematical form suitable for practising designers, but it will probably be some years before this is achieved. Meanwhile, the work which is being done throws light on some of the experimental results obtained from the tanks.

For accuracy the models used in testing tanks must not be too small, and they range in length between about nine and twenty-five feet. A testing tank becomes, therefore, an expensive piece of apparatus since its depth and width must be considerable in proportion to the model's dimensions, whilst it must also be long enough to give a run which allows time for the instruments to settle and readings of them to be made. A narrow tank causes inaccuracies, the waves made by the model rebounding from the sides of the tank and upsetting the readings. The larger tanks in England are about one-eighth of a mile in length, with a width of some 12 yds. and a depth of from 10 to 15 ft. (To raise the water level a few inches may cause considerable disruption of the civic water supplies, and to preserve the purity of so large a volume of still water is one of the many practical problems of tank testing.) Larger than anything in England is the Taylor Model Basin in Washington which has a 3000-ft. tank and employs 1100 people.

An electrically-driven carriage, to which the models are attached, spans the tank and runs on rails laid along the tank sides. The curvature of the earth has to be allowed for in the laying of the rails. The carriage is of considerable size, sometimes being called on to carry ten or more people, together with the controls and recording instruments, and the model is towed beneath, rigidly held to prevent yawing from side to side, but free to take up the fore and aft trim dictated by its speed. The towing pull of the model, which is the measure of its resistance, is taken up by a dynamometer.

In this and other European countries the models are made of paraffin wax, but in the U.S.A , where the climatic range prohibits the use of wax, wood has to be used. Wax has many advantages, the two most practical of which are its cheapness and the ease with which it may be worked. The important technical advantage lies in its consistency of surface finish. The quality of a model's surface has a big effect upon its measured resistance, and the utmost skill in the application of varnish on wood cannot achieve absolute consistency. The use of wax removes one source of experimental error.

Initially, a wax model is cast to shape in a clay mould. The hollow cast thus obtained is roughly in the shape of the completed model but uniformly larger owing to the mould having been made about an inch above size. In removing the surplus wax, the model is brought to its true shape. It is placed upside-down on a table above which are fixed fast-rotating mechanical cutting tools. These are carried on arms which move vertically or horizontally under the control of an operator. He has before him a plan showing the contours, in a horizontal plane, of the ship, and by following these with a pointer, the cutting tools are made to describe similar curves. They cut ridges in the model to a conformable depth. The model is then carved by hand down to the ridges, which form a guide to the correct shape. This is accurate, when the model is smooth, to within about one-thirty-second of an inch.

The model is fixed to the carriage and run in the tank at the speed necessary for comparison with the ship. Its resistance is measured, and from this value the calculated frictional resistance is subtracted. The difference gives the wave resistance of the model, and this, corrected for scale, gives the value for the ship concerned.

At the other end of the resistance problem is the question of propulsion. It must be ensured that the engine power is used without severe losses due to bad propeller design, and in the shaping of propellers the naval architect relies upon experiment, the achievement of the best hull-propeller combination being still largely empirical.

There are three principal varieties of model propeller experiments. Firstly, model propellers, made to a large scale, are run 'in the open'—that is, unattached to a model —when thrust and torque may be measured and the effects of altering the shape and thickness of the blades determined. Secondly, self-propelled models may be used. The screw is then turning in water disturbed by the ship's passage through it, an important influence on propeller design, and the effect of this may be observed. A difficulty of these experiments is that large-scale propellers are necessary for accuracy, which means in turn that models must be big, sometimes as much as 24 ft. in length, which is approaching the limit of size for wax models. There is a source of inaccuracy latent in these experimnets, since the pressure on the water's surface cannot be reduced to scale. Model propellers may be tested under scale pressure in a water tunnel, when a propeller revolves at its designed number of revolutions in a flowing stream of water at a corrected pressure. The necessity for using large models also causes difficulties in the branch of research concerned with the steering and manœuvring of ships, when self-propelled models are again used.

It is possible that the future may see more use made of water circulating channels, in which the model is fixed and the water allowed to flow past it. The saving in space and time would be considerable. It is sometimes not possible to make all the necessary readings during one run of a model in a tank, and between runs there must be an interval to allow the water to settle.

Since a ship spends much of her time moving amongst waves, the obtaining of evidence of a vessel's behaviour in a seaway forms an important part of model research. Tanks are provided with wave-making apparatus in which self-propelled models are tested. Instruments in the models measure periods of roll and pitch, and the behaviour of the models amongst waves may be recorded by cine-camera. The information thus obtained would be difficult to get by any other method. The results of full scale research are easily effected by such extraneous factors as tides, skill in handling the ship, fouling and the distribution of weights, whilst there is also the practical difficulty of making accurate, simultaneous observations. With models, any single feature may be separated and studied in isolation. One example comes to mind of information obtained from rough water model tests. It was desired to determine the most seaworthy shape of bow for a certain type of fishing craft. Three models were built with different designs of bow and tested in a tank and films of the models under way clearly indicated the most efficient shape. It would probably have been impossible to obtain such evidence from three different ships working under service conditions and, even had it been so obtained, it would have meant that two of the ships, built at considerable expense, would not have been of the most efficient shape. This is one example from thousands of the sort of work done in routine tank-testing.

A fascinating book might be written on the contribution of ship models towards winning the war. Their use was continuous, relating to all aspects of the sea affair, and testing tanks showed their value for work quite outside the range of that for which they were established. The work done on models of mines is an example of this. On one occasion, to test sweeping methods, a full-scale German magnetic mine was immersed in a tank; and models up to one-quarter of full size were used to examine the behaviour of mines under the action of tides, both when lying on the bottom and when afloat. The invention of a pressure mine, designed to be laid in shallow water and exploded by the change in water pressure induced on the sea bed by a ship passing above, made it pressingly necessary to study the exact nature of the pressure disturbance caused by various types of ship, and this investigation was made by means of models. But history may find their most striking use in connexion with the *Mulberry Harbour* which was towed across the Channel in units and sunk off Arromanches in Normandy to form a protective breakwater. The individual units had to be towed across the Channel quickly; therefore their resistance had to be kept reasonably low. But their shape had to be such that they would form an adequate wall against Channel seas. Moreover, it was essential that each unit should sink, on opening the sluice valves, rapidly yet without losing their stability and capsizing in the process. The first models capsized in the tank whilst sinking. There was no time for full-scale tests, and Mr. F. H. Todd, who was then at the National Physics Laboratory, did not exaggerate in saying that—". . . much of the success of the operations off Arromanches had its foundation in the model tests at Teddington."

The technique of model tank-testing is today so highly developed and the results it produces of such accuracy, that tank tests are an essential part of all major design work. During their years of work, the laboratories have collected a volume of data exceeding that of any single designer or even firm, and relating to all types of craft; and this, correlated with the performance of the full size vessels to which it applies, provides a remarkably sure yardstick with which to judge new designs. In fact, the tank test itself sometimes becomes almost irrelevant.

THE first phase of the Groundnut Scheme is now best regarded as a bold experiment which can set a new pattern for tropical agriculture and help to relieve the acute fats shortage. "What is being created in East Africa," says Leonard Cottrell, "is the prototype that must provide the data which, if given wide application in all tropical areas, will finally give the world its minimum requirements in oils and fats."

The Groundnut Experiment

LEONARD COTTRELL

"So you're going to see the Peanut Vendors?" inquired the fat man at a bar in Nairobi. "Waste of time, old boy, waste of time and money. The thing's a flop. Do you know"—leaning towards me confidentially—"there are piles of groundnuts in West Africa so high that a pilot thought his navigation was wrong and that he was over the Pyramids! No transport to take 'em away. And yet they're spending millions on this scheme in Tanganyika. Sending out a lot of amateurs, clerks and so forth, to tame the African bush!"

I found many others like him in Nairobi. Few people had a good word to say for the scheme, and as usual, those who were loudest in their denunciations knew least about it. For my part, I was reasonably unbiased. The B.B.C. had sent me out with Richard Lane, recording engineer, and a ton of gear, to report on the Groundnuts Scheme. All I wanted was to get a plane to Kongwa as soon as possible, but this was not easy. Eventually the R.A.F. came to the rescue and No. 82 Squadron offered to fly us to the Groundnuts H.Q. in a Dakota. Even then our troubles were not over, as the rainy season was on, and the C.O. of the squadron was justifiably anxious about getting a large aircraft down on to Kongwa's tiny airstrip when it might be waterlogged.

We took off from Eastleigh airfield, Nairobi, and flew for two hours over wild bush country which became increasingly mountainous; shortly after we had skirted the snow-covered Mount Kilimanjaro we ran into thick belts of rain clouds. When we caught glimpses of the ground it was always the same—thick forest furring the hillsides. Occasionally we saw a river valley, or a cluster of mushroom-shaped African huts in a clearing, but no roads, and only one railway. As Kongwa had no radio facilities we put down at Dodoma first to find out if anything was known about the condition of the Kongwa airstrip. A Rapide pilot who had flown in that morning reported that part of the runway was waterlogged, but that we could "probably" get in. We decided to chance it.

From the co-pilot's seat I had an exciting close-up of the Tanganyika bush as we skimmed across it at a low altitude. For nine months of the year it is as brown as a desert, but in March, during the rains, it was a deep, lush, unbroken green. Unbroken until we neared Kongwa itself, when suddenly there appeared great cleared patches of lighter green, patterned with long, curling lines. "Here we are," shouted the pilot over the intercom; "this is peanut-land." We were over the units Numbers One and Two, the curling lines were the 'windrows', following the contours of the land. The paler green between the rows were the groundnut-plants. It was one of the most stirring moments of my life—seeing the first year's results of this great enterprise about which so much has been written, but which so few have seen. As we banked over the cluster of tents which is Kongwa I could see the rough tracks bulldozed out of the bush, could see tractors, jeeps, but no airstrip. When we did locate it I could see nothing but a patch of cleared ground which looked hardly bigger than a football pitch, and I confess Lane and I prepared for the landing with some little unease. We 'porpoised' a bit as our wheels dug into the soft earth, but Flight-Lieutenant 'Larry' Brown got us down skilfully with room to spare.

So this was Kongwa. Red earth, white tents, forested hills—a billiard-table green. A hot, moist air. Scrub and thorn trees. Coal-black Wagogo tribesmen with frizzed hair and wide grinning mouths, and half a dozen brown-skinned officials in shorts and bush shirts, coming across the airstrip to greet us.

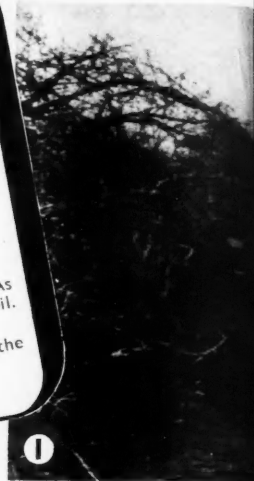
At the time I visited Kongwa there were only a handful of semi-permanent buildings, allocated to the senior officials. The remainder of the staff lived either in tents or 'bandas'. A 'banda' is a hut with mud walls and a tarpaulin roof. Most of the living quarters were under canvas and so were the administrative offices. As we drove along the dirt road to the 'banda' which had been allotted to us, we could hear the clatter of typewriters coming from tents which bore such signs as 'Area Manager', 'Chief Medical Officer', 'Chief Labour Officer', and so on. Kongwa is the administrative headquarters of the Scheme, controlling the plantations not only in the Kongwa area, but at Tobora, Nachingwea, Lindi and other places.

During the first few days I talked to senior officials, such as D. L. ('Bwana') Martin, who was then Agricultural Manager; Adam Noble, the Area Manager; and Dr. Hugh Bunting, the Chief Scientific Adviser. At this time the Scheme was still being run by the Managing Agency, the United Africa Company, which handed over in April 1948 to the Overseas Food Corporation. Martin and Noble have since left, though Bunting is still in charge of the scientific department. These men impressed me in two ways: first by their thorough grasp of the job, based on a lifetime's experience of tropical agriculture; and second, by their infectious enthusiasm which I soon found extended to practically all the staff, senior and junior. These were far from being the 'amateurs' scornfully described by my fat friend in Nairobi. Not that there were no complaints or criticisms. There were plenty, about hold-ups and delays, and particularly about housing and welfare. But from conversation I had with scores of 'groundnutters', from unit managers to tractor-drivers, I got an impression of keenness and high morale, and a determination to make a success of the Scheme.

The original estimate of the Wakefield Mission was for 15,000 acres to be cleared and planted in the Kongwa area

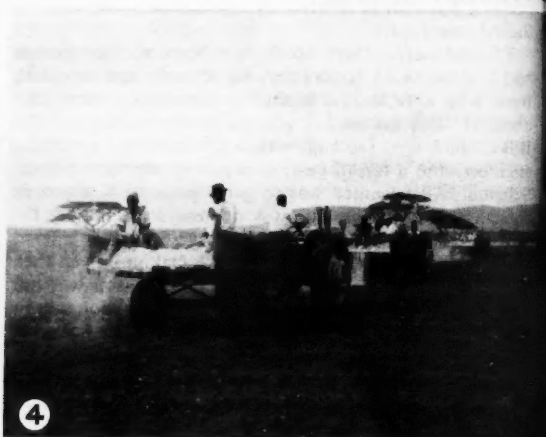
THE PILOT PROJECT AT KONGWA

1. A bulldozer clearing thorn scrub.
2. Every acre of scrub carries six to ten baobab trees, often ten feet in diameter. It took the special 'treedozer' two runs to uproot this typical specimen.
3. A general view of the Kongwa area. In the foreground is a field ready for ploughing. The second field is being cleared of roots left behind by the bulldozer. The cut scrub is seen piled up in windrows, and the whole area is terraced to prevent soil erosion.
4. Fertiliser is spread over the land.
5. The groundnut crop is ready for harvesting.
6. A groundnut plant lifted out of the soil to show the underground crop.
7. Mechanical diggers are used to lift the groundnuts, which are grown in rows like potatoes. As the digger passes down the rows, it lifts the groundnuts and shakes them free from loose soil. Side-delivery rakes then stack the nuts in long lines known as windrows.
8. Next a combine harvester passes down each windrow, bagging the groundnuts and throwing the leaves overboard in one operation.



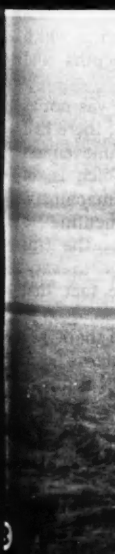
1

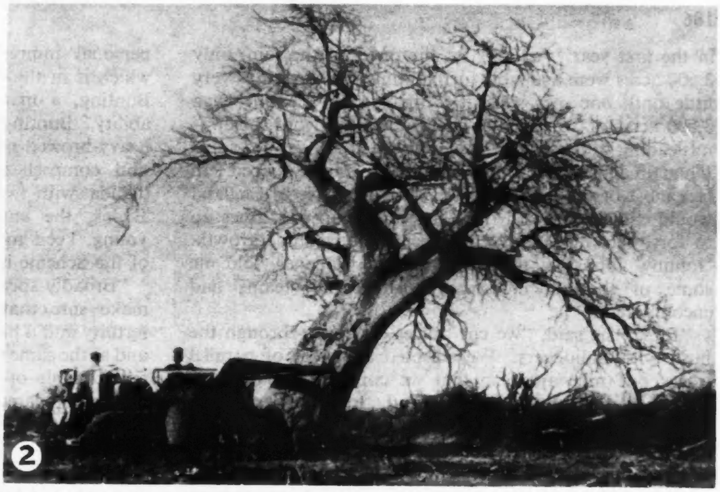
3



4

7




2


6

in the first year. Actually, at the onset of the rain, only 3,500 acres were available for planting, which sounds very little until one sees what it is involved in clearing even 3,500 acres of Tanganyika bush. Even the word 'bush' is misleading to those who have not visited Africa. I confess I had imagined low thorn trees fairly thinly spaced. In fact most of the Tanganyika bush is what we in England would call forest—and thick forest at that, with trees up to forty feet high and dense deeply rooted undergrowth. 'Johnny' Johnston, the Line Clearing Manager, told me some of the difficulties his bush-clearing teams had encountered.

"First," he said, "we cut 'traces' or roads through the bush with bulldozers. We adopted a system of parallel traces one mile apart so that we could then have mile squares for access to clear the land. But we soon found that we had to cut that mile into smaller areas; then, into each little square we set a team of bulldozers flattening all the bush as they moved along. Having flattened everything we packed the broken bush into hedges about ten feet high and fifteen feet wide, roughly following the contours of the land." (These were the 'windrows' I had seen from the air. They are intended to minimise wind and water erosion.)

Johnston then described the initial snags.

"The first serious trouble began when we started rooting. First we had to lift all tree-stumps from the ground and then to clear the ground of roots to a depth of fourteen inches. The roots were much more tenacious than had been thought, and in those days we hadn't equipment specially designed for the job.

"Then we had to go over the ground a second time before the ground was ready for the planters, and at this stage we ran into trouble from another quarter. The tractors with which we had been supplied were mostly from American war-dumps. They looked all right on the surface, but underneath they were in poor shape. One by one they broke down. We had very few spares at the time, so as the machines packed up we couldn't put them back to work."

Bush-clearing has other hazards. Readers who heard my programme "First Year at Kongwa" may remember Frank Richards, a tractor operator, describing his encounters with wild bees.

"Of course," he said, "if we worked overtime and looked before we started bush-bashing, we'd waste a lot of time, so we just had to bash on and take pot luck. Unluckily for me, the second day after starting off into the bush I hit a large tree and out came a swarm of the little b——s. They laid me on my back for three days, more dead than alive. My body was half as big again as normal."

It would be impossible in a single article to describe in detail the whole process of mechanised groundnut production, but here are a few personal impressions. First, the scientific department, which is in the extremely competent hands of Dr. Hugh Bunting, a man of formidable energy, knowledge and ability. Bunting is a South African, a powerfully built, heavy-browed man who answered all my questions lucidly and comprehensively. One afternoon he came to my 'banda' with two of his staff, Bond, the agronomist, and Evans, the entomologist, both, like Bunting himself, young, keen men, whose belief in the ultimate success of the Scheme is based on scientific knowledge.

"Broadly speaking," Bunting told me, "our work is to make sure that our method of farming will maintain fertility and a high level of yield, to control plant diseases, and at the same time to see that these methods are balanced and capable of going on for a long time without doing any major damage either to the soil or the general topography of the country in which we're working. One section of our work is connected with soil fertility and the general questions of the chemistry of the soil. Another section deals with the botanical or agronomic side. Here we're interested in developing rotations which will give us control of plant diseases and help us to maintain fertility, and which will provide us with other types of crops which may be of use to the world at such a time as the groundnuts are in sufficient supply."

Insect pests might threaten the success of the Scheme. Evans, the entomologist, told me that though there were a certain number of insects feeding on the groundnuts they were not in sufficient numbers to do serious damage. There is a possibility, however, that with the clearing of the bush large numbers of insects will be deprived of their normal food and may begin to take an interest in the groundnuts. Other problems are the prevention of damage to the stored products by insect pests.

Bunting and his men are preparing for all these possibilities. On another day I watched Bond, the agronomist, working on his experimental farm. A tropical rainstorm slashed down out of a leaden sky, but Bond, dressed only in a pair of sodden shorts, his moustache dripping, was plodding along the red furrows, following a machine which was planting groundnut seed at ranging depths and distances.

In the first year's planting, when the ground was not as smooth and free of roots as it might have been, there had been considerable unevenness in the planting, which is, of course, done by machinery. Bond was experimenting to find out what caused the gaps between the plants to vary. Was it due to the fact that the planter went too deep in some places and too shallow in others? Were the tractors being driven too fast? Was it due to the placement of the fertiliser, and so on?

"We're here," said Bond, "to deal with these problems as they arise, and to find out what we may expect in the future. Alternative crops, for instance. We have to face

Continued on p. 193

With the author (holding the microphone) are three of the scientists on the Tanganyika scheme; they are (*left* to *right*): Dr. A. C. Evans, Dr. Hugh Bunting and Dr. W. E. T. Bond.

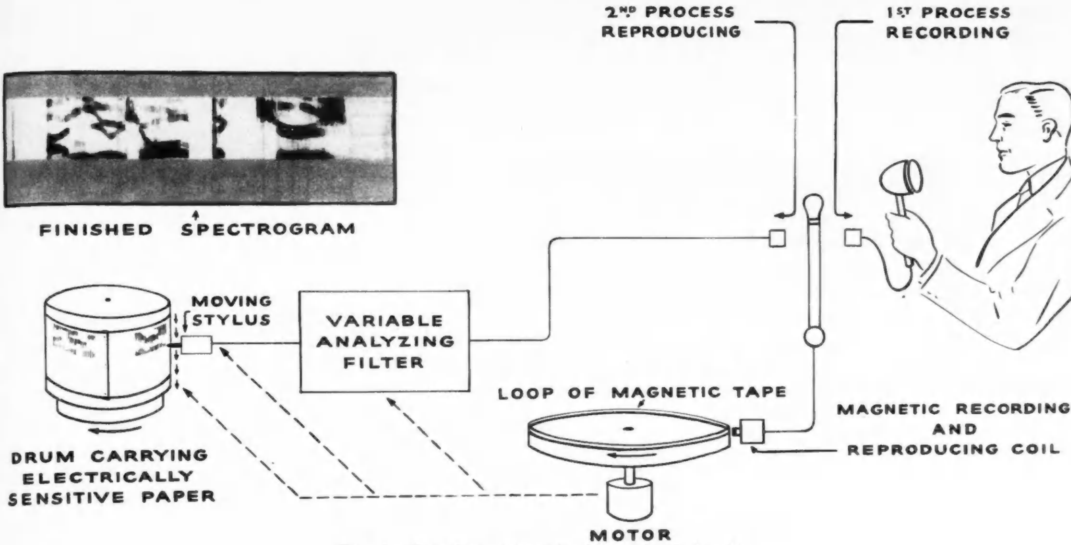


FIG. 1.—Sound spectrograph with mechanical stylus.

Visible Speech

IN a darkened room next door to the laboratories of the Bell Telephone Company in New York, two girls sit and chat vivaciously, facing a small screen. Both have been stone-deaf from birth. To both, speech means an unheard something that people do by contracting the throat, manipulating the tongue, and moving the lips.

The girls are conversing by 'visual speech'. In front of each of them is an ordinary telephone hand microphone; and across the small screen, only a few inches in area, there pass squiggles, dots, dashes, and criss-crossed lines in quickly changing patterns which the girls have learned to read and translate into 'talk'.

To deaf people all over the world, people who in all their lives have never heard a single sound made by the human voice, 'visual speech' offers fresh hope and the chance of making closer contact with those around them. It offers opportunity even to learn new languages and to speak them with a purity of accent which comes hard to normal people who learn inflexions in more orthodox ways.

"You can't hide anything from the visual speech machine," one of the research workers told me. "If your voice has a rasp it shows up in the patterns. Each inflexion, each emotion in the voice from anger to surprise is there—once you have learnt to read. If you strike a 'sour' note on an instrument, that registers too—if you can interpret it. The visual sound machine allows of no alibis. It may well revolutionise understanding of the whole business of sound."

What these scientists have done is to 'print' speech as patterns which can be read because they are characteristic and therefore recognisable—in much the same way as printed words can be read on sight because we recognise instantly the patterns made up by their component letters.

The three fundamental dimensions of a sound are *frequency*, *intensity* and *duration* (time). A machine that will give a *visible* translation of audible speech must be able to give a measure of all three dimensions. Because it sorts out the various sound waves of different frequencies the machine is called a *sound spectrograph*. Fig. 1 shows the principles underlying one particular form of sound spectrograph.

Let us see what happens after a sample sentence—*e.g.* "Speech we may see"—is spoken into the microphone. That sentence is first recorded on to the magnetic tape so that it can be played over and over again. The variable filter is then adjusted to let through those elements of sound falling within the 0 to 50 cycles-a-second band. The output of the filter is connected to the stylus resting on sensitive paper wrapped round the revolving drum, and the simple oscillations sorted out from the complex sound wave are recorded by the stylus on the moving paper. The intensity of the sound is registered by the darkness or lightness of the trace, so the record on the drum is one of varying shade.

The process is repeated for the 50 to 100 cycle band, 100 to 150 cycles, 150 to 200 cycles, etc., the stylus being moved downwards between each 'recording' so that a separate trace is obtained each different band width. The final result obtained when the succession of traces have been recorded on the drum is seen in Fig. 3; the pattern is characteristic of the speech sample, its key features being present whether the sentence is whispered or spoken normally, while different dialects bring about no more than a slight variation on the key pattern.

The sound spectograph perfected by the Bell Telephone Laboratories represents a big improvement on the device just described. The mechanical arrangement of stylus and drum is replaced by a far more sensitive mechanism; the pattern is sketched out by twelve traces, each trace being 'drawn' by light that leaves a track on a revolving fluorescent screen (Fig. 2). Instead of a single variable filter, there are twelve filters each corresponding to a particular band of frequencies. The fluctuating output from each filter actuates a glow lamp, and the twelve glow lamps are

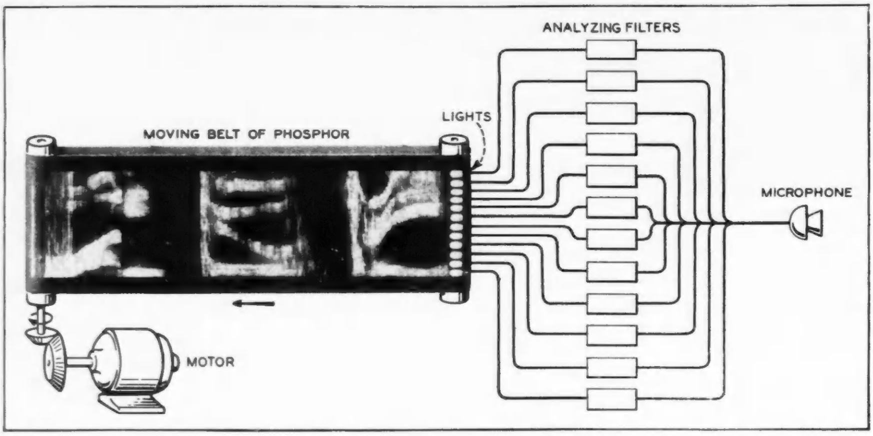


FIG. 2.—Diagram of the modern sound spectrograph.

arranged in a vertical row so the characteristic speech patterns are viewed moving across from left to right of the face of the instrument.

The instrument makes it possible to build up a catalogue of sounds, enabling one to say: "Now this is exactly what a dog's bark sounds like; this is a highly tuned motor; this is a sentence in Hottentot . . ."

Phoneticians see in 'visual sound' a way out of all their difficulties, because here at last is a fool-proof method of registration of every inflexion and combination of inflexions known to man. Dramatic schools see in it a way of teaching better diction by actually showing young actors exactly where they are at fault. The same goes for teachers of music. Industrialists see a way of listening to machines such as aero-engines in order to perceive 'knocks' hitherto of too short a duration for the human ear.

And scattered in small groups all over the world, according to reports at the laboratory, is another class of researchers who now feel that their own day is just around the corner. They are the bird-watchers. Ever since the first bird-watcher in a remote age lay for hours in some dank meadow trying to classify the whistles and cries of particular birds, ornithologists have deplored the fact that there has been no adequate musical notation by which these songs could be reproduced in printed form. 'Visual speech', when once they have learned to interpret the symbols, may prove the means of settling this problem neatly.

But, after all, the scientists say, it is in the teaching of those children who have never heard a sound since they were born that visual speech will come into its own. The average stone-deaf child cannot learn to speak more than six words in his first year at a school for the deaf, because of the difficulty of teaching. Training with visual speech apparatus has shown good results, although there is much still to be done.

Through this apparatus, the stone-deaf person is able to take his place in society and to share in life to the full. What is more it makes him a person of importance, a technical expert, so to speak, and this in itself makes for increased confidence. The scientist admits that the stone deaf, because they have everything to gain and nothing to lose, are much better readers of the squiggles and the patterns made by machinery, voices, and birds. It might well happen, then, that tomorrow's expert engine tuner, language coach, dramatic teacher, or expert on bird calls may be found among those deaf people who learn to form a more accurate idea of sound than those in full possession of their faculties.

DAVID CLAYTON.

(A very full account of this work of the Bell Telephone Laboratories has appeared as a 440-page book entitled "Visible Speech", published by Van Nostrand Company, New York.)

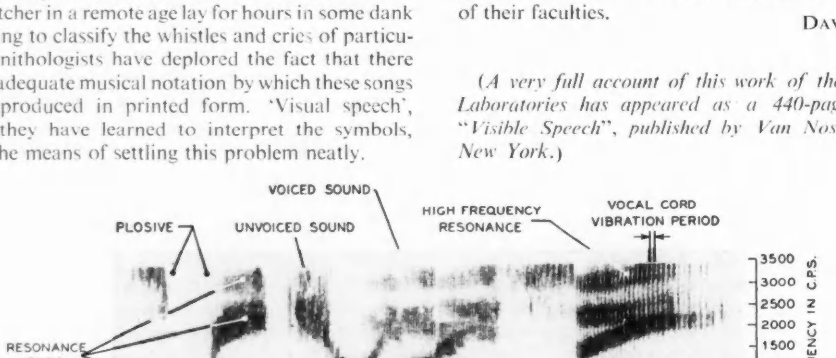


FIG. 3.—Sound spectrogram of the words "Speech we may see."

Science, Literature and Language

A. J. LAWRENCE

ONCE the scientist was literature's buffoon; later the Victorians were to respect him; to-day he is sometimes mistrusted, even feared. Indeed Bertrand Russell has gone so far as to suggest that, but for his indispensability, the scientist would today be persecuted all over the world.

In the changes in the relation between the scientist and society a very curious part has been played by the professional writers—the poets, novelists, playwrights and journalists. Owing to science as they do an immensely extended view of the material world, new depths of insight into human behaviour and copious additions to their very vocabulary, yet they have generally not shown themselves sympathetic to scientific research and the scientific attitude. This may be partly because they feel that, in spite of the advance of psychology, scientific methods cannot be applied successfully to the study of human behaviour and relationships, which is the writer's main field of activity. Sir Richard Gregory has complained that "with one or two brilliant exceptions, popular writers of the present day are indifferent to the knowledge gained by scientific study, and unmoved by the message which science alone is able to give". Fear of a tyranny of the rational over the aesthetic is one literary attitude. "A scientific tyranny denying the reality of importance of the super-rational values, would be as disastrous as a popular tyranny dictated by 'the common sense of the ordinary man'," writes W. B. Honey in *Science and the Creative Arts*. This is his reply to Professor C. H. Waddington who, in his book, *The Scientific Attitude*, claims that scientific thought has become the pattern for the creative activity of our age, and our only mode of transport through the rough seas in front of us. But this was, of course, written before the latest developments in atomic weapons, which have appalled the creative writer with the realisation that the immortality of his work—that comforting dream of unrecognised genius—is shadowed by the possible sudden death of the world.

Satires on Science

Two hundred and forty years ago, ironically enough, it was precisely for the apparently useless nature of their research that the scientists were attacked by the writers. When Swift's Gulliver arrived on the flying island of Laputa, where the reigning court of speculative scientists was established, he was first of all struck by the custom of employing flappers, or servants armed with rattling bladders on sticks. These servants roused their masters by lightly flapping them on the ears and mouths during conversation, "for their minds", wrote Swift, "are so taken up with intense speculations, that they can neither speak nor attend to the discourse of others, without being roused by some external taction. The flapper is likewise employed diligently to attend his master in his walks, and upon occasion to give him a soft flap on his eyes, because he is always so wrapt in cogitation, that he is in manifest danger of falling down every precipice, and bouncing his head against every post."

When the king of Laputa ordered a new suit of clothes for Gulliver, the tailor "first took my altitude by a quadrant, and then with rule and compasses described the dimensions and outlines of my whole body, all of which he entered upon paper; and in six days brought my clothes very ill-made, and quite out of shape, by happening to mistake a figure in the calculation". Gulliver found the inhabitants of the island "very bad reasoners, and vehemently given to opposition"; but what he most wondered at was their "strong disposition towards news and politics, perpetually inquiring into public affairs, giving their judgments in matters of state, and passionately disputing every inch of a party opinion. But I rather take this quality to spring from a very common infirmity of human nature, inclining us to be most curious and conceited in matters where we have least concern, and for which we are least adapted either by study or nature."

The women of the island, Gulliver found, condemned their scientific husbands and chose their gallants among the visitors; "and the husband is so wrapt in speculation, that the mistress and lover may proceed to the greatest familiarities before his face, if he be but provided with paper and implements, and without his flapper at his side".

As for Swift's idea of the usefulness of the scientist, this is summed up in Gulliver's visit to the Academy of Lagado, where "the first man I saw was of meagre aspect, with smutty hands and face. He had been eight years upon a project for extracting sunbeams from cucumbers, which were to be put into phials hermetically sealed, and let out to warm the air in raw, inclement summers. . . . I saw another at work, to calcine ice into gunpowder, who likewise showed me a treatise he had written concerning the malleability of fire, which he intended to publish." The other scientists Gulliver met there included one with a plan to "sow land with chaff, wherein he affirmed the true seminal virtue to be contained, as he demonstrated by several experiments which I was not skilful enough to comprehend".

Swift is the most vitriolic example of the influence of science on the writer, but he was not the first to satirise the scientist. Forty years before, the Fellows of the Royal Society were the target of several talented writers, including the dramatist Shadwell, creator of Sir Nicholas Gimcrack. Sir Nicholas, who was the chief character in Shadwell's immensely popular play *The Virtuoso* has "broken his brains about the nature of maggots . . . has studied these twenty years to find out the several sorts of spiders, and never cares for understanding mankind." Mrs. Aphra Behn, Steele and Addison all poked fun at the Fellows of the Royal Society. Addison made use of Shadwell's creation and writes an imaginary will of Sir Nicholas who, his widow explains, has died from a fever after running after an odd-coloured butterfly for some five miles.

A scientific club was still an appropriate subject for humour by the time Dickens was writing. The famous chairman of the Pickwick Club opened the book with his "Speculations on the Source of the Hampstead Ponds, with Some Observations on the Theory of Tittle bats." Mr. Pickwick on tittle bats is matched in the same novel by the scientific gentleman who from his back window observes

Mr. Pickwick's dark-lantern when Mr. Winkle is climbing garden walls to lay his soul at the entrancing Arabella's feet. When the scientific gentleman has come down to investigate, and has had his head punched briskly against the garden gate by Sam Weller, he is able afterwards to prove clearly that the light must have been the effect of electricity, owing to the fire which danced before his eyes and the shock which stunned him for a full quarter of an hour: "which demonstration delighted all the scientific associations beyond measure, and caused him to be considered a light of science ever afterwards".

The Impact of Darwin

However, the scientists were already becoming less easy game. Only a fool would have tried to make fun of a Davy or a Faraday. They were making their influence felt too deeply on everyday life. There was no mistaking the value of their work; men saw it everywhere. They represented not dreams but progressive civilisation. The scientists were to take a terrible revenge on the writers who had satirised them, by taking away their faith and shaking the foundations of their complacence. There was a careless time, between the two great wars, when it was fashionable to write of the Victorian Age as a period of profit-making and cant, when life was stuffy but stable. The less superficial historian has always known that the second half of the nineteenth century was in fact, for many intellectual men, a time of terrible doubt and painful readjustments. The evolutionary theories of the scientists had knocked away the props of conventional religion. Matthew Arnold's poetry reflects a collapse of faith. The later poetry of Tennyson circles round one theme—the pathos of man doomed to wander between faith rooted in fear, and a widening scientific knowledge that dispels the fear but leaves him without hope.

Nor were the writers alone to suffer. The literary critic, Sir Edmind Gosse, has described in *Father and Son* how the mind of his father, an eminent marine naturalist and a fanatical Calvinist, was torn by the doctrine of natural selection. "Every instinct in his intelligence," says Gosse, "went out at first to greet the new light. It had hardly done so, when a recollection of the opening chapter of Genesis checked it at the outset." He determined to have nothing to do with the terrible new theory. He had at the same time a profound esteem for Darwin and Hooker, and therefore he chose geology, rather than zoology or botany, as the field of an impetuous experiment in reaction. He published his own theory—that there had been no gradual modification of the surface of the earth, or slow development of organic forms, but that when the catastrophic act of creation took place, the world presented, instantly, the structural appearance of a plant on which life had long existed. "The theory, coarsely enough, and to my father's great indignation, was defined by a hasty press as being this—that God hid the fossils in the rocks in order to tempt geologists into infidelity. . . ."

The evolutionists were bound to win; but the acceptance of their ideas came all the more quickly because of their gifts of expression. Darwin would have disclaimed any right to be considered as a literary artist, yet the clarity of his style, and the very quietness with which he presents his conclusions, give to much of his writing the quality of a work of art. T. H. Huxley was just as remarkable for his clear, insistent prose. And it is only fair to recall here that those earlier science-lovers, so much maligned by Swift and others, had done good service to the language. They rejected the Aristotelian, pedantic style of the university professors, and sought to write about their work in a language the general public could understand. One of the first secretaries of the Royal Society, Wilkins, had been a leader in developing the new form of writing. His sentences are short, pointed and exact; and Gosse considers that justice has not yet been done him as a pioneer in English prose. The 1702 edition of the History of the Royal Society by Thomas Sprat, one of the original Fellows, was described even by Swift as the best book in the English language.

The Influence of Wells

It was almost at the end of the last century that the literary world was able to see the positive results of scientific influence on a writer of genius. H. G. Wells, who studied under T. H. Huxley at the Normal School of Science (which later became the Royal College of Science), was not the first writer to handle scientific discovery as a theme (Jules Verne had long preceded him); but he was the first to make vivid and authentic the very vocabulary and atmosphere of scientific research. He would still have been a great writer if he had not been a scientist, but he would not have written *The Time Machine*, *The Invisible Man*, *The War of the Worlds*, or *The First Men in the Moon*. Nor perhaps would he have gone on to devise and publish his plans for world Utopias. Wells is a most fascinating case of the mingling of the creative and scientific instincts. Instinctively, as a creative artist, he admitted the irrational in man, and used it sometimes to produce brilliant humour; constructively, as a scientist, he was irritated by the irrational, and felt that the scientific attitude could and must be applied to human behaviour. Twentieth-century literature needed more scientific writers like Wells, capable of destroying popular misconceptions of science, of giving man an objective view of his own littleness, of recalling him from his preoccupation with business and national politics to something approaching a sense of proportion. Wells always asserted that he was a journalist rather than an artist, but even when he was at his most journalistic and Utopian it is dangerous to under-estimate him. The only other great literary-scientific figure of the end of the century was Henry Havelock Ellis, whose essays on creative writers show the same powers of scientific research as his famous treatise on sex. Shaw's claim to be accepted as a man of science, implicit in "Back to Methusaleh, a Metabiological Pentateuch" and other of his writings, cannot be substantiated; he has perhaps the mind, but not the background and analytical training of the scientist in literature.

Science and the Novelist

If science and literature had continued the curious partnership begun by Wells, modern man might have different reading habits and a quite different outlook on the universe. But the First World War seems to have broken off the partnership; the scientist became more and more a specialist; and the literary development was towards doubt and cynicism and experimenting with the styles and forms of prescientific periods. There was also a lack of literary genius.

In the disillusionment science seemed rather pitilessly to be disclaiming responsibility. Science might lead the way to truth, but it was the truth of Capek's *Robot*, of a film like *Metropolis*. Writers remembered Samuel Butler's *Erewhon*, written back in 1870, in which an intelligent society rigorously suppressed machines, on the ground that they were bound to evolve and destroy their makers. Psychology was a useful weapon to the novelist, but it was placed in his hand at a dark time. Aldous Huxley wielded it for purposes of satire, to bring the intellectual and the scientist down to a little below human level. He nearly always writes with great vividness and clarity. He is at home with the arts and has great scientific knowledge. Yet he is the product of an age which cannot find anything to believe in. The result was *Antic Hay*, *Point Counter Point*, and *Brave New World*. The effect of Wells's writing was to arouse belief in the scientist's desire to create a more reasonable world, in which unnecessary human suffering might be reduced or eliminated, and man might be brought to organise himself for his own survival. This positive attitude has inspired much of the literature on the pioneers in medicine, on the Curies, Edison, Pasteur. The effect of Aldous Huxley, on the other hand, is to arouse distrust of the scientist as a manipulator of the unpleasant and the potentially dangerous. The Huxley scientist has become the irresponsible bogeyman to keep simple people awake at night, and he is all the more disturbing because, away from his laboratory, he is just as instinct-ridden as the rest of men.

"Where now are They," asks the poet Auden.

> Who without reproaches shewed us what our vanity has chosen,
> Who pursued understanding with patience like a sex, had unlearnt
> Our hatred, and towards the really better
> World had turned their face?
>
> There was Nansen in the north, in the hot south Schweitzer, and the neat man
> To their east who ordered Gorki to be electrified;
> There were Freud and Groddeck at their candid studies
> Of the mind and body of man.
>
> Nor was every author both a comforter and a liar;
> Lawrence revealed the sensations hidden by shame,
> The sense of guilt was recorded by Kafka,
> There was Proust on the self-regard.
>
> Who knows? The peaked and violent faces are exalted,
> The feverish prejudiced lives do not care, and lost
> Their voice in the flutter of bunting, the glittering
> Brass of the great retreat,
>
> And the malice of death. For the wicked card is dealt, and
> The sinister tall-hatted botanist stoops at the spring
> With his insignificant phial, and looses
> The plague on the ignorant town.

The effect of the war has been to continue the divided attitude of the writer. When he has scientific experience, he writes with understanding. A highly entertaining example is the novel *No Highway* in which Nevil Shute, formerly an aircraft designer, has written of civil aviation research and the testing of new planes. From the war itself came Nigel Balchin's *Small Back Room*, a brilliant novel describing a war-time scientific activity most likely to excite admiration—the de-fusing of a new kind of anti-personnel bomb at the risk of the scientist's life. Differing in almost every other respect, the two novels have this in common: they both emphasise the personal integrity of the scientist, who is portrayed as indifferent and even antagonistic to commercial interests and bureaucracy. It is Aldous Huxley again, in *Ape and Essence* who floodlights the other side of the picture—the scientist enslaved by national rulers for purposes of human destruction. In this book the latest atomic developments have led to the most terrifying and pitiless satire on humanity written in the last twenty years. It would seem that the wheel had turned full circle since Gulliver voyaged to Laputa.

Vocabulary enriched by Science

Scientific progress has influenced literature in one other important way. It has played a continuous part in changing and adding to the language, through which the writer expresses his thoughts. For at least five hundred years it has been importing, inventing and changing the meanings of words. It was from the Arabic that Chaucer introduced *azimuth*, *nadir* and *zenith* (*Treatise on the Astrolabe*, 1391). The Arabic words *alcohol*, *alkali* and *amalgam* were introduced at about the same time. Chaucer was also one of the earliest users of scientific words taken from Greek and Latin, including *equator* and *equinox* (Latin); *minute* (Latin), in its meaning of one sixtieth of a degree ; and *horizon* (Greek).

The Renaissance led to adoption of many more Greek and Latin roots for scientific purposes. *Acid*, *hydraulic* and *suction* were introduced by Francis Bacon, who also used the word *dissection* for the first time in its modern meaning. By this time the science of astronomy had begun to modify the meanings of words already existing. Once Galileo had made men realise that the earth was no longer the centre of a static universe, new meanings were attached to atmosphere, earth, sky and star. Newton's discoveries led to *gravity* taking on its great new meaning, and the new words *gravitate* and *gravitation* were formed. Owen Barfield, in his *History of English Words* thinks that from the time of Newton a certain change of meaning spread over all words containing the idea of attraction. The phenomena of gravitation and magnetism are now familiar; but in Newton's time there was no half-way house in the imagination between actual dragging and pushing, and emotional forces such as love or hate. Science changed the meanings of other words at about the same time. *Mechanic* lost its old meaning of "pertaining to manual labour", and began to be applied to machines. The word *machine*, formerly used in the sense of plot, intrigue, or any kind of structure, was first used in its modern meaning. All these words came into current literary use. The school of metaphysical poets led by John Donne (d. 1631) shows a deep influence of science on poetic vocabulary.

The word *automatic* was first used in English in the eighteenth century. The earliest quotation in the Oxford Dictionary is taken from David Hartley, who wrote in 1748:

> "The motions of the body are of two kinds, automatic and voluntary. The automatic motions are those which arise from the mechanism of the body in an evident

manner. They are called automatic from their resemblance to the motions of automata, or machines, whose principle of motion is within themselves. Of this kind are the motions of the heart and peristaltic motion of the bowels."

In 1802 Paley pointed out the difference "between an animal and an automatic statue", and sixty years later a writer on physics, after speaking of the amoeba as being "irritable and automatic", added that:

> "Automatic . . . has recently acquired a meaning almost exactly opposite to that which it originally bore, and an automatic action is now by many understood to mean nothing more than an action produced by some machinery or other. In this work I use it in the older sense, as denoting the action of a body, the causes of which appear to lie in the body itself."

From the end of the eighteenth century the trickle of new scientific words became a steady stream, and by the end of the nineteenth it had swelled to a flood. The new words were nearly always drawn from Greek and Latin roots. Philologists complained that the dictionaries were becoming burdened with an enormous mass of scientific terms which were not English at all except in their termination and the pronunciation inferred from their spelling. Bradley suggested that the adoption of an international language for science would bring about the disappearance of what he called "these monstrosities of un-English English".

By this time every branch of science needed its special vocabulary consisting of words which could be limited to one precise meaning, and it was only by forming words from Greek and Latin that the need could be satisfactorily met.* It would have been possible to construct a vocabulary for modern science consisting of popular words used in specially restricted senses, and of compounds formed out of native British elements. Indeed in Germany this has been done to a very large extent. But from the scientist's point of view it is often a grave disadvantage for scientific words to suggest everyday meanings, for they may evoke misleading associations. A term which has been taken from a dead language, on the other hand, can be rigidly confined to a special meaning.

It is a pity that no complete list has yet been compiled of scientific words and phrases which have passed into general and literary use. It would provide an interesting record of the impact of scientific discovery on the public mind, especially since the days of newspapers. The Darwinian controversy, for instance, resulted in curious additions to the journalist's vocabulary. All ooze became "primeval ooze", leaders on European politics began to contain such phrases as "the survival of the fittest". How suddenly Darwin enlarged the language can be gauged by the fact that *heredity* is recorded by Francis Galton as having been considered "fanciful and unusual" in 1859 when the *Origin of Species* was published. Nowadays wherever newspapers are published, and women's journals carry articles on nutrition and health, anyone with a fair education understands words compounded with *thermo-*, *kine-*, *hydro-*, *phon-*, *geo-*, or *chromo-*.

* There is no international lexicon of scientific and learned terms, and the International Scientific Congress of 1922 failed to agree even to a proposal for limiting to nine the languages in which scientific works might be written to qualify for international recognition.

Some of these words would never have passed into the language if they had first been scrutinised by a British equivalent to the French Academy, but no such body exists in this country. (The Royal Society in 1664 included in its early programme a study and reform of the English language, but this side of its activities did not develop.) The Oxford English Dictionary, which writers use to test a word's respectability, is simply a vast list of precedents. Any scientist, poet, government department or journalist may put a new word into circulation; the only test the word must surmount is that of general acceptance. The freedom of this process has led to many unpleasant hybrids, even though the English language has at the same time become the richest in the world, with the possible exception of Russian. But philologists must regret that the more modern word-builders could not follow the example of scientists like Faraday, who was so careful of his new scientific vocabulary that he sought the advice of a Greek scholar for the purpose. Sound choice of Greek roots provided all the new terminology for his description of electro-chemical phenomena: *electrolyte*, *electrode*, *cathode*, *anode*, *cation*, *anion*, and *ion*. Contrast these with a group of words introduced by others, compounded with the Greek word *tele* (afar). The chronological order is *telescope* (17th cent.), *telegraph* (1790); *telephone* (1876); *telepathy* (1880). All these have sound Greek derivations, but then comes *television* (1909), a bad hybrid of Latin and Greek, and last of all *teleview*, an etymological horror. It seems to be the moderns who cannot make good words. Even *vitamin* and *wireless* seem to have been rather mediocre attempts, in comparision with the importance of the things they described. But perhaps even they are better than the American *avigation*, meaning 'aerial navigation'.

There is a special form of snobbery connected with scientific words—a desire to hide whatever is out of date, conventional or even faintly disreputable under imposing nomenclature. Mr. H. L. Mencken (in *The American Language*, Supplement 1), tells how a lady named Miss Sothern once wrote to him thus from a Fifth Avenue address:

> "I am writing this letter to you because I have read and admired your book on the American language and believe that semantics can be of some help to me. It happens that I am a practitioner of the fine art of strip-teasing. Strip-teasing is a formal and rhythmic disrobing of the body in public. In recent years there has been a great deal of uninformed criticism levelled against my profession. Most of it is without foundation and arises because of the unfortunate word strip-teasing, which creates the wrong connotations in the mind of the public. I feel sure that if you could coin a new and more palatable word to describe this art, the objections to it would vanish and I and my colleagues would have easier going. I hope that the science of semantics can find time to help the verbally under-privileged members of my profession. Thank you."

In his reply, Mr. Mencken suggested the scientific word for moulting, which is 'ecdysis', and from which both 'ecdysist' and ecdysiast' are derived. (Mr. Ivor Brown, who quotes the whole story in *Say the Word* recalls that ecdysis was used by T. H. Huxley in discussing "Man's Place in Nature"). Mr. Mencken's suggestion was adopted by Miss

Sothern, and a Society of Ecdysiasts, Parade and Specialty Dancers was formed. However, the empress of all regular ecdysiasts, Miss Gypsy Rose Lee, later rejected the word indignantly, and defined Mr. Mencken as "an intellectual slob". She added: "He has been reading dictionaries. We don't wear feathers and moult them off. What does he know about stripping?"

Miss Lee's insistence on strict definition did her credit. But popularised scientific words do not need to be accurately used in order to gain their currency. Fowler drew up a list of formerly technical or scientific words and phrases which in popular use very often misrepresent their original meaning. The list included: (from Mathematics) *arithmetical progression* and *geometrical progression, to the nth degree, to be a function* (or *percentage*) *of*—no more than to be 'part of'; (from Chemistry) *acid test*, a phrase beloved of the late President Wilson. That list is already twenty years old; we can now add to it. As Bernard Partridge points out (*Usage and Abusage*) the followers of Freud have much to answer for. *Inferiority complex*, for example, is often used, quite wrongly, to denote a morbid sense of one's own inferiority. Yet in psychology the word complex is the complete field, the full set, of ideas and feelings in reference to a particular object or sentiment or emotion. Inferiority complex, therefore, denotes the entire field of one's feelings and ideas concerning one's personal inferiority. A complex need not necessarily include abnormal ideas and feelings. Without looking very far at least a dozen misused scientific words can be found, as *allergic, uninhibited, moron, pathological, mutation, reaction.*

A survey of this length can deal only in outline with the relations of science with literature and language It is clear, however, that the writer's method has undergone great changes in the last fifty years as a result of scientific discovery and the scientific attitude. Science has meant successive readjustments to the creative writer's standard of values. It has caused doubts and questionings in minds still rooted in the culture of Greece and the Renaissance, while often supplying them with vocabulary to express themselves more exactly. In the next fifty years this process is likely to be accelerated. The scientists may be the cause of altogether extraordinary developments in literature, if society produces more writers nourished with scientific learning and with the scientist's approach to human problems.

THE GROUNDNUT EXPERIMENT—*Continued from p. 186.*

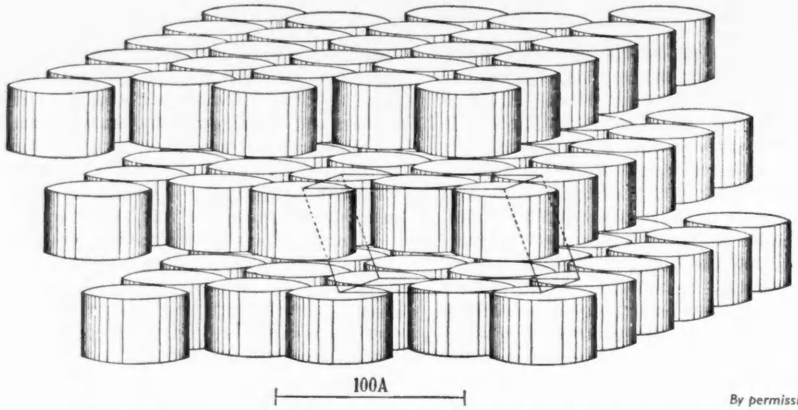
the possibility that sooner or later we will get pests and diseases which will attack groundnuts; so it is well to have other oil-bearing crops which we can grow in rotation with groundnuts. One of the most promising is sunflower, and we're also experimenting with sesame, oil seed, castor and sorghum."

I have little space left in which to deal with housing and welfare, both of the European and African workers on the Scheme. When I visited Kongwa, the chief object of criticism, particularly among the mass of workers, was lack of decent accommodation. The founders of the Scheme faced a dilemma. Were they to arrange for accommodation first, build houses, hospitals, schools, etc., before they began bush-clearing, or were they to go straight ahead with clearing and planting and let the provision of permanent accommodation wait? They chose the second alternative, wisely in my view, but there is no doubt that the permanent success of the Scheme will not be assured until all the staff and workers, European and African, are comfortably housed and provided with all the necessary amenities. During the past year much has been done. Blocks of semi-permanent flats are gradually taking the place of tents and 'bandas', schools are being provided and more 'groundnutters' have been able to bring out their families. Health is another big problem at Kongwa. Fortunately it is not in a tsetse-infested area, but mosquitoes are numerous at certain times of the year, and anti-malarial precautions are strictly enforced. In March everyone was expected to sleep under nets and take Paludrine regularly. Sanitation was still in the earth-closet stage, and sooner or later most people had to endure an attack of 'Kongwa tummy', a painful intestinal complaint which sometimes developed into dysentery. All these problems will eventually be overcome with the development of better sanitation and the enforcement of a higher standard of cleanliness among the African servants.

Finally, a word about the Africans. It was difficult to obtain from them a frank opinion on the Scheme, as they usually preferred to say whatever would please the white 'bwana'. I was also handicapped by my ignorance of Swahili, so that all my interviews were conducted through an interpreter. Local labour is recruited from the Wagogo tribe, who are not, either in physique or intelligence, equal to such tribes as the Matabile, the Masai and the Kikuyu. To the Wagogo the Scheme will bring many benefits, better nutrition, medical facilities and the opportunity of improving their living conditions by modern methods of agriculture. One of their chiefs, Semango, told me that his people liked the Scheme because his young men were able to learn European methods. Some of them have become quite skilful tractor-drivers and European foremen are encouraged to pick out men who show unusual intelligence for special training. In addition to the Wagogo, workers here have been recruited from more distant parts of Africa. Most of them live in labour camps, and when I was at Kongwa, very few had been able to bring their families with them. Eventually whole new villages will have to be built near Kongwa to house the African workers.

As for the larger aspects of the Scheme, others can speak with more authority than I. The recent debate in Parliament has revealed that some of the difficulties anticipated by the scientists at Kongwa have already occurred. Certainly the original estimates of the Wakefield Mission were wildly optimistic and it now seems that several years must elapse before the scheme can show tangible results. All I can say as an observer is that I was very impressed by the keenness and ability of the men I met, and that the difficulties they are facing are much more formidable than I had realised. Given time and adequate backing, I believe they will succeed. At the same time it should be realised that even the Groundnuts Scheme, vast as it is, cannot make good the present world fats shortage.

What is being created in East Africa is the prototype that must provide the data which, if given wide application in all tropical areas, will finally give the world its minimum requirements in oils and fats.



By permission of the Royal Society.

FIG. 1.—How the molecules are arranged in the methaemoglobin structure; layers of closely packed molecules are seen separated by liquid. One unit cell is shown in the foreground on right.

The Architecture of Protein Molecules

Dr. GABRIELE RABEL

MARSHAL BLUCHER'S motto was: "Keep apart for the march but unite for the battle!" Physics, chemistry and biology, which duly kept apart for a long time while they were on the march, have now successfully united their forces for many a battle. One of the objectives which is just about to yield to their common onslaught is the secret of how the protein molecule is constructed. And so we note the odd situation that crystallographic departments of physical laboratories—regions which we might consider the most rigidly inorganic of all inorganic realms—have been invaded by 'biological cells'. One such cell we find for example in the Cavendish Laboratory at Cambridge where a team of young scientists led by Dr. M. F. Perutz and Mr. J. C. Kendrew have made the structure of the protein molecule their particular concern.

Says Professor Sir Laurence Bragg: "The elucidation of the structure of such enormous and complex molecules is the most ambitious problem as yet tackled by X-ray analysis and success would cast a flood of light on the structure of living matter."

Let us briefly recall what X-ray analysis is.

Everybody knows that sound goes round the corner and that light as a rule does not. But that is only true if the plane hit by the light is so large that, so to speak, the waves do not find any corners in it. If, however, the structure of the object hit is very fine, about the size of the wave-length, the waves do find corners in their way and do go round them. In this case the light is not reflected in conformity with the rules of geometrical optics but scattered—*diffracted*, to use the customary term—in all directions. As waves coming from different points interfere, they alternatingly reinforce and annul each other and the resulting maxima and minima of light form a *diffraction pattern*.

A lamp gazed at through a fine silk handkerchief displays all kinds of diffraction patterns according to the fabric. If a glass plate is finely ruled so as to form a grating, and if a beam of monochromatic light falls on this grating, a series of dark lines appears. If the beam is not monochromatic, but mixed, each wave-length has other maxima and minima and the result is a diffraction spectrum.

At the beginning of this century, the German physicist von Laue had the ingenious idea to try whether the regular arrangement of atoms, which one had all reason to expect in a crystal, could be used as a natural diffraction grating. Visible light was not suitable for this purpose, because the wave-lengths of visible light are of the order of 4000–6000 Ångström units (1 Ångström unit is equal to 0·00000001 centimetres.) The spacing of the atoms in a crystal could be expected to be about 1000 times as small, and this must be the order of the wave-length of radiation applied if the atomic lattice was to act as a diffraction grating.

So X-rays were applied. The experiment answered Laue's question in the affirmative—thereby not only demonstrating the real existence of an atom lattice within a crystal but at the same time establishing the wave character of X-rays and their similarity to visible radiation beyond any possible doubt.

From the position of the spots on a diffraction picture and from their intensities, the spacing between the atoms and often the exact position of every atom can be computed. The Braggs, father and son, have worked out systematic methods for the interpretation of crystal diffraction patterns, and now the knowledge thus acquired is being applied to the study of biological objects—firstly to molecules, secondly to cells and tissues.

The chemistry of living things now centres, to a large extent, on the study of their proteins.* Even the simplest organisms, such as bacteria, contain probably hundreds of thousands of different proteins, and altogether there may be hundreds of millions of them. Most proteins are

* An article on the general properties of proteins by Dr. Perutz appeared in DISCOVERY, November 1944. There the reader will also find a description of the function and chemical build-up of haemoglobin.

known to contain the same elements in the same proportions. In a few cases also, the molecular groups, such as amino acids, from which they are built up, are known. But the geometrical arrangement of these chemical units within the molecule is still a matter of guesswork. It is here that X-ray analysis comes in. The beautiful diffraction patterns which are obtained from protein crystals leave no doubt that these crystals show a regular spacing down to atomic dimensions.

Crystals are built up by the indefinite repetition of a fundamental geometrical unit called the *unit block*, otherwise termed the *unit cell*. X-ray analysis gives, comparatively easily, the size of these blocks and the length of the spaces between them.

"Single crystal analysis of proteins," writes Dr. Perutz, "appears at first sight a task of forbidding complexity, since even in the smallest proteins so far examined the relative positions of 2000 atoms would have to be determined. So very little is known, however, about the structure of the crystalline proteins that much valuable information can be derived even without embarking on the obviously hopeless task of finding the exact position of thousands of atoms in the unit cell.

"In favourable cases one can find the shape and external dimensions of the protein molecules, the amount of bound water that is attached to them, their packing in the crystal and the nature of the intermolecular forces in the crystal lattice."

Dr. Perutz did his chief work together with two women scientists, Joy Boyes-Watson and Edna Davidson. He chose horse methaemoglobin * for the purpose because this substance is available in large quantities, is stable and easy to crystallise, and the arrangement of the molecules in the crystal is exceptionally simple. The molecular weight is 66,700. It was found that two such molecules, chemically and structurally identical, form a unit cell.

Although the whole protein *crystal* is monoclinic,† the individual molecules, of which the crystal is composed, are cylindrical and the crystal gets its monoclinic shape from the manner in which these cylindrical discs are piled up (Fig. 1). The circular base of the disc has a diameter of 57 Ångström units, its height is 34 Ångström units. In normal wet crystals, only 47·6% of the unit cell volume is occupied by the haemoglobin molecules, the remainder consists of the liquid of crystallisation. One of the first steps of the analysis was aimed at finding out whether the haemoglobin molecules themselves are sponge-like and take up the liquid, or whether the liquid merely fills the spaces between them. This was investigated by allowing heavy ions to diffuse into the crystal. The fact that such ions do diffuse into the crystal, if introduced into the suspension liquid, had been revealed by density measurements, for the density of the wet crystal varies if the composition of the suspension liquid varies while the dimensions of the unit cell remain constant. From the change produced in the diffraction pictures by the presence of those heavy ions, the X-ray analyst found it possible to infer that the bulk of the liquid lies *between* the molecules rather than *within* them. The liquid of crystallisation appears to fill the gaps between successive layers of cylinders and also the interstices between neighbouring cylinders within each layer. These interstices are small as the cylindrical discs are closely packed.

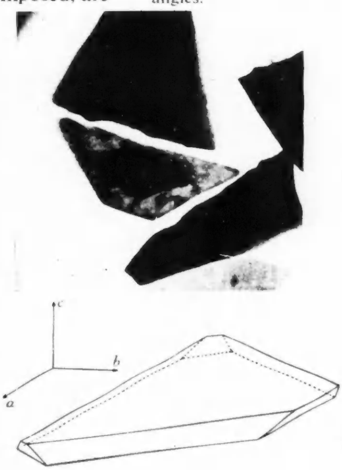
While the general pattern of the X-ray pictures seems to be the same in all protein crystals there is "a bewildering variety of different structures" when it comes to detail. The haemoglobin of one species of animal differs from that of another, though no difference can be detected between haemoglobin from one specimen of a particular species and another specimen of the same species. As Dr. Perutz has said, "Proteins show species specificity. This means that the chemical composition and molecular structure of corresponding proteins in different animal species are usually different. On the other hand, at least so far as X-ray data are concerned, no differences between corresponding proteins in different individuals of the same species have yet been detected."

In a recent paper to *Nature*, J. C. Kendrew and M. F. Perutz describe the unmistakable differences which prevail between the haemoglobin of adult and foetal sheep. That the haemoglobin of mother and foetus is not the same has been known for many years, and physiologists have studied these differences by various physical and chemical methods. The most important point is that at a given oxygen pressure the foetal haemoglobin is oxidised to a greater extent than the haemoglobin of the adult animal. This suggested a different structure which X-ray analysis might possibly clear up.

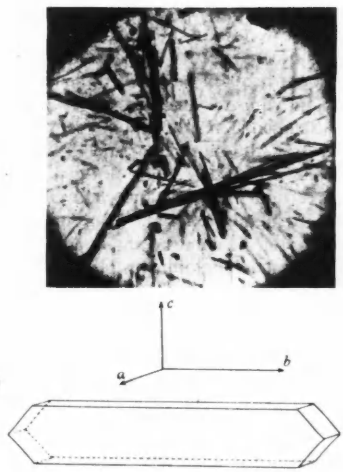
Sheep methaemoglobin was chosen for this study because

* *Methaemoglobin* is a compound of haematin and globin, differing from *haemoglobin* in that the iron in the molecule is in its trivalent (ferric) state, while in haemoglobin it is in the bivalent (ferrous) state.

† A monoclinic crystal has the three crystal axes of unequal length; one of their intersections is oblique, the other two are at right angles.



FIGS. 2-3.—Micrograph (× 20 approx.) and drawing of crystals of methaemoglobin from adult sheep.



By permission of the Royal Society

FIGS. 4-5.—Micrograph (× 20 approx.) and drawing of crystals of same protein from foetal sheep.

both the adult and the foetal blood of sheep is readily available. The results were as follows.

The methaemoglobin of adult sheep crystallised in only one form, namely, in plate-like triangular crystals belonging to the monoclinic system (Figs. 2 and 3). The unit cell has the dimensions 164 × 70 × 66 Ångström units. Under identical conditions the haemoglobin of a *foetus* under 120 days of age appeared in two crystalline forms, which were completely dissimilar from each other and from the adult form. As a rule this foetal haemoglobin was deposited as orthorhombic needles (Figs. 4 and 5), but once these appeared together with monoclinic plates of greater thickness and parallelogram-like shape. This latter form is probably less stable and therefore rarely seen. The dimensions of the orthorhombic needles were 99 × 78 × 54 Ångström units. The differences between the adult and both foetal crystals extend to all measurable characters. Thus foetal haemoglobin consists of four identical and symmetrically arranged sub-units of molecular weight 17,000 and tends to split into 'quarter molecules' in dilute solution; adult haemoglobin, on the other hand, forms an asymmetrical unit of molecular weight 68,000 and shows no sign of dissociation in dilute solution.

If foetal and adult haemoglobin are mixed, crystallisation is strongly inhibited, and such crystals as do appear are either of the adult or of the foetal type, depending on which kind of haemoglobin is present in greater quantities. A similar inhibition of crystallisation is observed in a foetus just before birth. It is assumed that, up to the 120th day of pregnancy, foetal haemoglobin only is present while later adult blood mixes with it.

The development of X-ray analysis using very low angles has made it possible to study the mode of packing of colloidal particles even if these are not arranged in a crystal lattice, and a micro-camera constructed by J. C. Kendrew, which works with a beam of only 0.01 millimetre in diameter, promises to supply diffraction patterns from single red blood corpuscles. Unlike the electron microscope, the micro-camera allows materials to be examined in the wet state, although the enormous doses of X-rays required to record the different patterns photographically would probably make it difficult to keep cells alive.

In *Nature* a year or so ago (February 7, 1948), Dr. Perutz discussed a result which French scientists inferred from their X-ray pictures, namely, that the haemoglobin molecules in the red cell are not distributed at random but that a certain mean distance between neighbouring molecules is frequently realised. Combining the French results with his own, he came to the conclusion that the arrangement of the haemoglobin in the blood corpuscle is just what it should be if it is to fulfil its task in the most efficient manner, that is, to take in a maximum amount of oxygen and to pass it on with maximum speed.

Recently an interesting plant virus was submitted to X-ray analysis by Professor J. D. Bernal and his assistant Dr. Carlisle. This object had been sent to them by Kenneth Smith and Markham, who had first studied its, in some ways, exceptional biological properties. One remarkable feature is that the "turnip yellow mosaic virus", as it is called, is transmitted by a biting insect. In nature, the flea beetle only was observed at this work, but when various insects were artificially fed with a virus preparation, many were found able and willing to act as carriers, provided they possessed one positive and one negative character—they had to have biting mouth parts and had to lack salivary glands.

It seems that all plant viruses so far studied are nucleoproteins. By repeated centrifuging Dr. Kenneth Smith and his collaborators succeeded in separating their turnip yellow mosaic virus preparation into two components, one of which settled more slowly and therefore remained at the top while the other collected at the bottom. These two components, both specific to the disease, form crystals of the same form and almost the same size, they contain the same amino acids in the same proportions, they seem identical as to their protein constitution, and yet one of them spells life and the other death, for only the bottom layer contains nucleic acid and only the bottom layer is infectious. Injection of this portion produces a serum with a very high content of antibodies.

Both crystals, the protein and the nucleoprotein, were examined by Professor Bernal. The crystals were very small, of less than 0·1 mm. size and poorly developed. However, their octahedral bipyramidal form was clearly recognisable. The diffraction pictures could be interpreted as obtained from a lattice of the diamond type; cubic with an atom at the centre of every face. There must be eight molecules per cell in such a lattice and the distance between two particles was computed to 306 Ångström units.

The crystals containing nucleic acid and those containing none appeared almost completely similar, except for two rather puzzling features. (1) The time of exposure required by the virus crystals was only 96 hours, whereas the non-virus took 144 hours. (2) The non-virus is slightly larger than the virus. The side length of the virus lattice was about 706 Ångström units when wet and 528 Ångström units when dry, while that of the non-virus was 725 Ångström units in wet and 550 Ångström units in dry condition.

The fact that without nucleic acid the crystals are slightly larger than with it suggests that the nucleic acid may exercise some attracting and condensing force on the particles, and one might find a confirmation of this assumption in the fact that the scientists so far found it impossible to isolate the nucleid acid out of nucleoprotein without destroying the protein.

Professor Bernal thinks that more differences may well be discovered between the infectious and the non-infectious portion of the turnip yellow mosaic virus when larger samples will be available for investigation, so that wide angle diffraction becomes possible.

REFERENCES

A good survey of this subject by Dr. M. F. Perutz appeared in *Research*, February 1949.

See also:

J. C. Kendrew and M. F. Perutz, *Proceedings of Royal Society* (A), Vol. 194, 1948, No. 1038.

J. D. Bernal and C. H. Carlisle, *Nature*, July 17, 1948 (Vol. 162); *Nature*, July 24, 1948.

J. Boyes-Watson, E. Davidson and M. F. Perutz, *Proceedings of Royal Society* (A), Vol. 191, 1947, No. 1024.

The fate of schemes for the protection of Britain's flora and fauna will depend to a great extent on the final form in which the National Parks Bill is passed. Mr. Muirhead, who used to edit DISCOVERY, is uniquely qualified to write this critique of the Bill: for a number of years he has been editor of both the "Blue Guides" and the "Penguin Guides", and consequently he has an exceptional knowledge of the British countryside.

The National Parks Bill

L. RUSSELL MUIRHEAD

ON the principle of being grateful for small mercies, the National Parks and Access to the Countryside Bill, which received its second reading in the House of Commons on March 31 and April 1, should at least be accorded an interested reception. The mere fact that it has been officially recognised as desirable that something should be done towards preserving parts of the English countryside is a matter for national congratulation. Whether the Bill, if it becomes law, will have this effect, is another matter. Many powerful interests will conspire to see that it does not; and the Bill, as it stands, is a very tentative weapon of defence. Still, it *is* a weapon of defence.

Mr. Silkin, as Minister of Town and Country Planning, introduced the Bill in a long and agreeable speech, which until near its end, did little more than translate the terms of the Bill from the customary official jargon into plain English. In doing so, he inevitably exposed the woolliness of the various provisions contained in the Bill; and, whether intentionally or no, he summed up the whole position in a single sentence at the close of his speech: "If we have a bad Minister or a bad or unsympathetic Government, the National Parks will not be well administered." As he somewhat naïvely went on, "One must recognise that." That is, indeed, what a great many people do recognise and that is what they are worrying about.

It was quite obvious, in the debate which followed, that members on both sides of the House were extremely dubious about what would be the attitude of the various Government departments towards the National Parks; and in that they echoed the feeling of such of their fellow-citizens who have given the matter any thought at all. Really, indeed, the Bill is an anachronism; it would have been effective enough, as it stands, against "wicked landlords" and other minor horrors of the nineteenth and earlier centuries; against the juggernaut activities of the Board of Trade or the Service Departments, when these mighty institutions really get the bit between their teeth, the Bill indeed seems somewhat of a broken reed.

It has rightly been insisted, both in the House and in the columns of the National Press, that the central administration of the National Parks should be a body of "high standing, expert qualification, substantial independence, and permanent constitution", as recommended in the Hobhouse Report, which itself quoted from the earlier Dower Report. As it is, there is bound to be a great deal of doubt about who is to have the last word—the local planning authorities, the National Parks Commission, the Ministry of Town and Country Planning, or the Government. It is obvious to the meanest intelligence that while these various authorities are coming to a decision, a single Government department can, if it will, step in and secure for its own purposes yet another few thousand acres of what the Bill describes as "open country"—and which won't be "open" any more, as far as the general public is concerned.

A good phrase for the Commission, as it will exist if the Bill passes into law unamended, was coined in a letter to *The Times* composed by the chairmen of three organisations representing the most important potential National Park Areas: the Lake District, the Peak District, and Rural Wales. "A dim outlier of the Ministry" was what they called it; and, with its curious jumble of joint boards, nominees of local authorities, advisory committees, and so on, that is just what it is. What is required is not this kind of body, but an authoritative Commission for each national park area, with some real authority investing it with powers to combat the sudden pounce or the insidious undermining of any Government department. Most people, indeed, like Mrs. Castle, M.P., "do not trust Government departments to be the guardians of the aesthetic interests of the country". At present, failing a violent public outcry, Government departments have the last word. The National Parks Commission, as planned in the Bill, is not going to deprive them of this privilege.

A good deal of ink has been spilt over the question of 'local' versus 'national' representatives on the various park commissions, it being generally assumed that a 'local' man is more likely to be swayed by what are politely called 'economic' considerations. This seems to me to be uncharitable (to say the least of it) and—more important—to be a divergence from the main line of attack. As Mr. Silkin said, the success of the Bill (of this one or a better one, it might be said) will have to depend "on the courageous, determined, and imaginative spirit in which it is carried out by the parties concerned." I find it very difficult to believe that local authorities are entirely lacking in men of good will and good sense from the National Parks point of view. Not *all* district councillors are entirely venal, as some arguments put forward recently would seem to imply. Gilbert White, for example, would have made an excellent chairman for a Hampshire National Parks Committee—and he was a 'local' man, if ever there was one.

No! The main line of attack must be towards achieving greater and more definite powers for the various commissions dealing with the proposed National Parks, whether these commissions are of local or of national composition. They must protect and foster the interest of the average citizen in much the same way as the judiciary power is supposed to do, and, in fact, often does, especially against the arbitrary incursions of Government departments on individual rights. Your true bureaucrat says "I don't like

lawyers"; let him also say "I don't like National Parks men", and it will be a sign that the object of the long series of Royal Commissions on National Parks will have at last been achieved.

A good many other important points are left in an indeterminate condition. In the first place the actual definition of a "National Park" is left a trifle nebulous. In the words of the Bill, it is "an extensive area of outstanding beauty, suitable for open-air recreation by the general public, but where the normal life of the existing community goes on". This, as the Minister did not fail to explain, hardly falls into line with the dictionary definition of a park, national or otherwise, and in itself it fairly bristles with prickly problems. Can the general public indulge in "open-air recreation" and yet allow life of the existing community to continue to be normal? Mr. Silkin thinks this desirable, and I heartily agree; but is it possible? The public, of course, are being "put on their honour not to do anything which would create wilful damage to the farming interests". This is the sort of pious hope that infuses so much of our 'humanitarian' legislation nowadays and brings to mind thoughts of "human perfectibility" and the philosophy of Jean-Jacques. In fact, of course, the public will have to be educated, and educated quickly and thoroughly, in the reasonable methods of enjoying the privileges that are being showered upon them. As Mr. W. S. Morrison pointed out, the danger of damage arises "much more from ignorance than wickedness, though there is sometimes an element of wantonness which is a sort of amalgam of the two". Can the public be educated out of this wantonness in time? The ramblers' associations have been working away at it long enough, in all conscience, but it still persists. I am reminded of the story of the new Glasgow Zoo, opened not many months ago. Proper precautions were taken to protect the public from the lions; but no one thought of protecting the lions from the public, who expressed their interest and appreciation by hurling stones and brickbats into the luckless carnivores' enclosures.

Many of the clauses of the Bill deal with access to open country; but just what is 'open country'? Without quibbling, let us take it for granted that it means uncultivated land. Except by raising fires (as they do regularly every year) the public can do comparatively little damage on uncultivated ground; but the question of access opens up many possibilities of trouble, as uncultivated ground is often reached by way of cultivated territory, where the damage caused by the 'uneducated' (in our special sense) can be of untold magnitude and can further widen the ever-widening rift between the urban and the rural populations, which this Bill is laudably designed to mend. If, however, the Minister does not insist on going the whole hog at once, a great deal can be done to avert this danger. As Mr. Philips Price pointed out, much has already been done by the method of limited access allowed in the National Forest Parks; and, of course, it will be quite possible not to allow unlimited access to the entire area of any given National Park, until the ruling authority (whoever that may ultimately prove to be) is satisfied that the public is educated up to the requisite level.

Other unresolved problems are evident in the provisions dealing with the "killing, taking, molesting, or disturbance of living creatures of any description", or "the taking of, or interference with, vegetation of any description" in a nature reserve. A nature reserve requires good husbandry almost as much as agricultural land. No land in England or Wales is absolutely in its natural state; our climate will not allow vegetation to remain static; and as anyone who has had to do with a nature reserve will admit, the task of maintaining the desired ecological balance is one that requires continual vigilance. The same applies to the necessity for controlling the faunal population. In fact, the whole procedure is the work of highly trained specialists, and no general purposes committee with vague powers will be able to carry out the job.

The planners themselves are not above suspicion. Dr. Thomas Sharp demonstrated this only too clearly when he revealed the essential vulgarity and obtuseness of the answers of 90% of the candidates to a question in a recent examination of the Town Planning Institute. In their view, fountains, concrete paths, and pretty flower-beds were the ideal adjuncts to an ancient village pond. It seems we are to have long-distance footpaths provided for us; let us at all events ensure that they are not concreted throughout their entire length. And what are we to think of Mr. Silkin's Ministry itself, which has just prostituted Kensington Square to the demands of big business—against the express recommendation of the L.C.C., which is not in itself a specially sentimental body?

I suppose we must resign ourselves to a public of spoon-fed ramblers, with beautifully signposted long-distance and short-distance paths; with definite information that they are "coming into a national park or an area of exceptional beauty"—surely a matter of individual judgment, this last—with the provision of "accommodation, meals and refreshments (including intoxicating liquor), of camping sites, of parking-places", etc., etc. This is a long way from the old-fashioned method of knocking about with a one-inch Ordnance Survey map and seeing that all shut gates were kept shut and all fires put out carefully. But if our rambles must be regimented, let them at least be regimented by an authority whose orders cannot be countermanded by any intrusive Government department.

In the first day's debate on the Bill, Sir Arthur Salter produced an unnerving and minatory list of activities of a kind likely to destroy a national park, on the part of both local and national authorities, but especially—and far more dangerously and destructively—the latter. How fully justified his warning is, was borne out by the letter to *The Times* (April 9, 1949) announcing further claims on Dartmoor by the Services. The accusations in it were partially answered from the Ministry of Town and Country Planning; but there are evidently conflicting interests at work.

Nothing could make it more evident that a strong central authority dealing with National Parks is needed, supported by a pyramid of special local authorities. The Bill, as it stands, is better than nothing—if it does nothing else it will lead to the production of maps showing which footpaths are rights-of-way, and which are not—but it must be provided with a much stiffer backbone if its provisions are not to be twisted aside by any determined Government department. The ancient wickedness of the Bad Sir Jasper pales into insignificance beside the anonymous brutality of the bureaucratic 'They'.

Far and Near

DDT *versus* Malaria

THE discovery of powerful insecticides such as DDT opened up the prospect of eliminating disease-carrying insects such as the louse and the mosquito. Typical of areas in which attempts have been made to reduce the incidence of malaria by eradicating the mosquito is Cyprus, and here most encouraging results have been obtained. The objective of the Cyprus campaign was to clear the whole island of the various mosquito species carrying malaria. Against the mosquito larvae a 3% to 4% solution of DDT in gas oil was used, and for buildings with high ceilings and in certain inaccessible places DDT and gammexane smoke was also employed. The flit gun was the major weapon in the attack on breeding places which began in April 1946. It should be mentioned that no major effort was directed to the drainage of marshy breeding areas, though several such areas exist.

The results of the campaign, published in the *British Medical Journal*, 1949, April 30, p. 767, were most impressive. In 1944, two years before the campaign, 7686 cases of malaria were reported; in 1948, after the strongholds of the mosquito had been reduced, there were only 406 cases. In 1944, 51·9% of school-children examined had malarial parasites in their blood; in 1948 none of the blood films from several hundred infants under two years living in villages which had previously been highly malarious contained malarial parasites.

Weather Forecasts by 'Phone

THE possibility that one day in the not too distant future we may be able to dial 'WEA' and obtain a local weather forecast was conjured up by the Under Secretary of State for Air (Mr. de Freitas) in the House of Commons on May 12. He had agreed that the weather forecast would be much more accurate if it covered a small area and a short period of time. He thought such local weather forecasts might best be supplied by a system such as dialling 'WEA' for 'weather' and getting on to a talking clock in the same way as is done when dialling 'TIM'.

A question as to the accuracy of weather forecasts (April 27) brought a reply from the Secretary of State for Air, that "the general accuracy of weather forecasts has been 85–88% in the last few years and checks of recent months have shown that the accuracy has improved to 90% for forecasts of rain or no rain in the London area". The official reply stressed the need to remember that a weather forecast "cannot at present be more than an assessment of probabilities".

Compound E and Rheumatism

WHEN sufficient supplies become available the hormone known as Compound E is to be thoroughly tested in Britain to establish whether it can cure or relieve rheumatoid arthritis. Compound E, whose chemical name is 17-hydroxy-11-dehydrocorticosterone, is derived from the adrenal gland. Encouraging results have been reported by American workers who tried it on a limited number of patients suffering from rheumatoid arthritis.

Director for Government's Development Board

LORD HALSBURY, research manager of Decca Record Co. Ltd., has been appointed director of the Government's new National Research Development Board.

Research Planned by Himmler

LIGHT on the pseudo-scientific character of 'research' sponsored by the Nazis in Germany is shed by a letter recently found in the government archives in Berlin. It was written by Himmler and addressed to "SS Oberfuehrer Professor Wuest, Ahnenerbe, Muenchen".

'Das Ahnenerbe' was a race research station and its curator, Walter Wuest, was 'professor for Aryan Culture and Linguistics'.

Herr Himmler's letter accompanied a copy of an article dealing with ice ages and the present ice cover of the earth, and in it Himmler expressed the wish that after the war these problems should be intensively studied "by all those scientists who can, in some way or other, contribute to the changing shape of our earth by ice or absence of ice, by the change of land and sea. These questions are not only most interesting scientifically, but they are in my opinion of paramount importance for the future of our race on the earth. We must see to it that we settle at least the best portions of our race in *a country which is geologically secure for many hundred thousands of years*."

Six M.I.T. Scholarships for British Students

THE Massachusetts Institute of Technology has granted scientific and technical scholarships to six British students for this year's summer course in Cambridge, Massachusetts, beginning on June 6 and ending on September 16, 1949. More than 35 candidates applied.

The six successful candidates are: Mr. David D. Carrow, West Amesbury; Mr. Archibald C. Doherty, Norton, Stockton-on-Tees; Mr. John F. Dowler, Buxton; Mr. John H. Harlock, St. John's College, Cambridge; Mr. Frederick J. Hyde, Birmingham University, Edgbaston, Birmingham; Mr. Peter Godfrey, Thames Ditton.

Foreign Members of the Royal Society

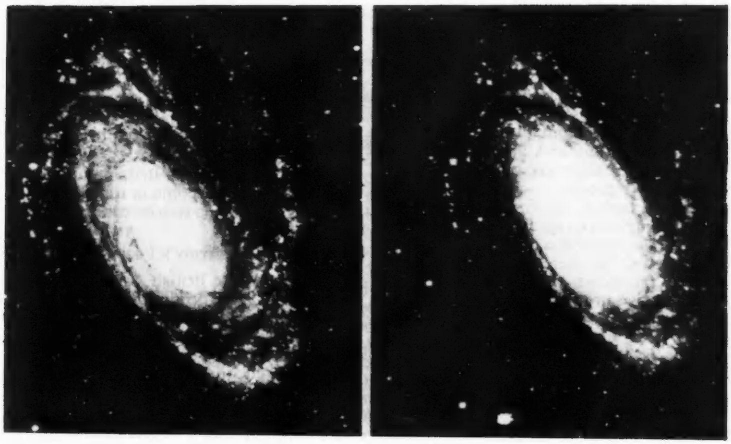
AT a meeting of the Royal Society held on May 12, the following were elected Foreign Members of the Society.

PROFESSOR PERCY WILLIAMS BRIDGMAN, Research Professor of Physics at Harvard University, whose pioneering work in the field of very high pressures is world-famous.

PROFESSOR NORMAN LEVI BOWEN (Washington), Petrologist at the Geophysical Laboratory, Carnegie Institution, Washington.

PROFESSOR MAX VON LAUE, of the Max Planck Institute, Göttingen, Germany. It was his work which established the basis of modern methods of X-ray crystallography.

PROFESSOR ERWIN SCHRÖDINGER (Dublin), senior professor and Director of the Department of Theoretical Physics Dublin Institute of Advanced Studies, Dublin. Professor Schrödinger's contributions to quantum mechanics won him a Nobel Prize in 1933.



The power of the 200-inch Hale telescope on Mount Palomar is illustrated by these two pictures of the spiral nebula Messier 81. The left-hand picture was taken with the 200 inch telescope; that on right by the 100-inch on Mount Wilson. The 200-inch picture contains much more detail. The nebula shown is some 300 million light-years distant.

Chestnut Blight

THE import of sweet chestnut plants into Britain has been forbidden because of the threat of chestnut 'blight', a disease which has so far received little publicity in this country. It is caused by a fungus, belonging to the family Sphaeriaceae of the Ascomycetes, *Endothia parasitica*. The fruit bodies of this fungus are rusty or orange-red pustules closely similar to those of the relatively innocuous *Endothia radicalis*, which may often be found on dead branches of sweet chestnut (*Castanea sativa*) in Britain.

Of Asiatic origin, *Endothia parasitica* was first noticed in New York in 1904. It spread rapidly among the various species of *Castanea* and the damage done by 1911 was conservatively estimated at £5,000,000. Some 95% of all infected sweet chestnut trees are killed within fifteen years of infection, and this year Dr. G. F. Gravatt of the U.S. Division of Forest Pathology has stated that the fungus has killed nearly all the American sweet chestnuts in their natural range in the eastern and middle Atlantic U.S.A.; "in areas where the blight has been present twenty-five years or more, a very few large trees are still alive and struggling against the disease, but each year a few more of them die". Separate infections have occurred in California, Oregon and British Columbia, but drastic control measures seem to have checked the spread of the disease, and the Oregon infection has probably been eradicated. The fungus has also been found on two or three species of oak, and on red maple, staghorn sumach and shagbark hickory. (It does not parasitise the last three trees, growing on them solely saprophytically.) Only on chestnut is the fungus virulent.

In Italy *Endothia parastica* was first found near Genoa in 1938. It is now firmly established not only in that area but also in three others—near Lucca in Tuscany, north-east of Venice, and east of Naples. The disease is proving as deadly as in America: the Italians prefer the term 'bark-cancer' to 'blight'. Though the infection is spreading more slowly than in America, yet it is causing the utmost concern, for Italy has around 1,750,000 acres of sweet chestnut (i.e. about half the whole area at present devoted to forests in Great Britain) and almost the entire population of some regions is dependent on chestnut products—nuts, timber and poles, and tannin. In Tuscany the disease is spreading more rapidly than elsewhere.

Endothia parasitica has been reported from Spain but here the infected trees have so far shown strong resistance.

The spawn or mycelium of *E. parasitica* grows (as the term 'bark cancer' suggests) in the bark, and it spreads into the sapwood. The vital cells are destroyed and the trees are in time girdled as surely as by an axe.

The fruits of the fungus are, as already noted, rusty or orange pustules. From these are produced minute spores by different processes. One consists in the extrusion of yellow, hairlike 'spore horns', composed of spores (of the kind called 'pycnidiospores') which are sticky and commonly spread by insects,

The chestnut-blight fungus. Magnification: ×4. The objects looking superficially like tendrils are sticky masses of pycnidiospores extruded from cavities below the surface of the bark. (*Courtesy of Division of Forest Pathology, U.S. Plant Industry Station, Beltsville, U.S.A.*).

birds and other animals. The other consists in the extrusion from the pustules (usually in drier weather) of small sacs which later burst to release spores (technically known as 'ascospores') which are wind-borne.

American and Italian efforts to cope with the disease are directed largely to the selection and breeding of resistant strains and hybrids of *Castanea*. Both Japanese and American chestnuts seem to be specially susceptible, and the European chestnut has proved only a little less vulnerable, but one or two Chinese species (particularly *C. mollissima*) have shown most promising resistance. American and Italian pathologists are co-operating: viable pollen for some of the hybridising experiments has been sent by air from one country to the other.

In Kent and Sussex the sweet chestnut is grown for the production of hop poles and material for the familiar cleft-chestnut fencing. Good chestnut coppice of this kind is probably the most valuable and lucrative forest crop in Britain, and chestnut blight could become in the absence of rigid precautions, a serious economic pest.

Science and the Army's Food

VICTUALLING the British Army during the late war was a prodigious task. Quite apart from the enormous quantities of food involved were the scientific aspects of deterioration of prepared foods, and difficulties encountered in connexion with dehydration, storage, metallic contamination and loss of vitamin content of canned goods all demanded investigation. A recent paper by Dr. J. King in *Chemistry and Industry*, 1948, No. 47, p. 739, reviews the achievements in this field.

It was realised in the immediate prewar years that canned foods would be of overwhelming importance to a modern army in the field. As a result of large-scale experiments it was established that food in cans did not become contaminated by lead or tin, and that there was no appreciable loss of vitamin content or quality during prolonged storage. During the peak year 1943, two thousand million cans were produced for the Army alone. The total output for the whole war period was five times that number—about enough to provide all the inhabitants of Britain with 200 tins a head. This colossal number of cans required 900,000 tons of steel, 12,000 of tin and 5000 of solder. The cans were generally of the A1 tall type, each with a capacity of 16 oz., and were produced at the rate of 300 to 350 per machine per minute. Most of the can-making machinery was of American origin. To economise in the use of tin, the Americans developed an electro-tin-plating process Finally 'tin-less' canning was perfected, the cans being coated internally with a protective heat-resistant lacquer. The Germans solved the same problem independently in identical fashion.

Corrosion during storage was serious where the cans were stored underground; mineral salts proved corrosive and reduced the store life to a few months. This difficulty was surmounted by a spray application of zinc in a plastic condition. Alternatively the outside of the can was coated with a rubberised paint containing zinc dust.

Self-heating cans frequently were the sole means of providing a soldier with a hot drink before going into battle. A thermite-type heater was developed which could be ignited by a simple fuse. This unit, incorporated within the can, produced 30,000 calories in 2 to 5 minutes. In Arctic zones a unit producing twice this quantity of heat was used.

For special purposes, fuel blocks of 1 oz. of hexamethylenetetramine were supplied. These blocks could heat 1½ pints of water in a mess tin in 12 minutes.

Dehydration was widely used, especially for vegetables, meat and milk powder. The method prevents bacterial deterioration and when used in conjunction with an inert gas packing autoxidation of fats was avoided, a method which also stabilised the vitamin content and flavour.

Death of Silicone Pioneer

THE chemist whose pure researches laid the basis for the commercial development of the organic silicon compounds, known as silicones, died on May 2. He was PROFESSOR F. S. KIPPING, F.R.S., and occupied the chair of chemistry at University College, Nottingham, for many years.

Another important scientist who died since our last issue went to press was SIR ROBERT ROBERTSON, F.R.S. He was a great expert on explosives, and for a long period (including the years of World War I) he was Director of Explosives Research at Woolwich Arsenal. Afterwards he became Government Chemist, which position he held from 1921 until his retirement from Government service in 1936. When World War II began he returned to Woolwich Arsenal and remained there as director of the Armament Research Director until 1946.

200-ft Tower for Radio Research

The Research Laboratories of the General Electric Company at Wembley are actively engaged on research and development in connexion with long-distance point-to-point communications on very short radio waves, a natural outcome of the firm's wartime interest in the development of valves and radar systems in the centimetric waveband. Present commitments include the London to Birmingham radio link for television, on behalf of the G.P.O.

Very short radio waves are essentially optical in character and travel in straight lines resembling a searchlight. It is, therefore, necessary to avoid obstruction of the line of sight of the linkage path by hills, buildings or trees.

In order to provide such an optical path from the Wembley Research Laboratories a tower, 200 ft. high, is being erected which will be suitable as the Wembley terminal of experimental radio links, enabling a large amount of apparatus there to form an essential part of such schemes. It will also be suitable for work on many other projects at very short radio wavelengths. It is a lattice steel tower standing on a base 45 ft. square, each corner leg being set in a reinforced concrete foundation 10 ft. square and 11 ft. deep. A passenger lift will give access to two cabins situated one above the other at the top of the tower. Each cabin will be octagonal, about 11 ft. wide and will have an external balcony on which the very directional short wave aerials will be mounted. The cavity walls of the cabins will be thermally insulated and electrically screened.

When completed the tower will provide a very valuable extension to the telecommunications facilities of the Wembley Laboratories.

A Handbook for Uranium Prospectors

To promote exploration throughout the Colonial territories for ores of uranium, the Geological Survey of Great Britain D.S.I.R. (Atomic Energy Division), has produced a short technical pamphlet entitled "A Prospector's Handbook to Radioactive Mineral Deposits". The pamphlet is obtainable from H.M. Stationery Office, Kingsway, London, W.C.2, Price 6*d*., by post 7*d*. It provides the fundamental scientific information necessary to guide prospectors, geologists and mining engineers in their widespread search for those mineral deposits which form the basis of all developments in the field of atomic energy.

Films about Metals

A new film catalogue, "Films about Metals", has been published for the Scientific Film Association by Current Affairs, Ltd., 19 Charing Cross Road, London, W.C.2., price 3*s*. 6*d*. (3*s*. 8*d*. post free, 2*s*. 8*d*. post free to S.F.A. members).

This catalogue, prepared in conjunction with the Joint Committee of Metallurgical Education, is the first of a series on specialised subjects which will ultimately replace the S.F.A.'s "Catalogue of Films of General Scientific Interest". Titles of about 200 films are given together with running time, gauge and distributor. Wherever possible, a brief synopsis of content is given and a number of films have been appraised for audience suitability. A wide field of subjects is covered from the basic metallurgical processes to the utilisation of metals in bridge construction and the manufacture of car bodies.

A Great Entomologist

By the death of Dr. Augustus Daniel Imms, F.R.S., on April 3 at the age of 68, Britain has lost one of her most eminent entomologists. A graduate of Birmingham University, he took his B.A. at Cambridge by research, where he worked under Sir Arthur Shipley and Dr. David Sharp. He then went to India to become Professor of Biology at Allahabad University, and afterwards Forest Zoologist to the Indian Government. On his return to England in 1913 he was appointed Reader in Agricultural Entomology at Manchester University, and it was during his tenure of this post that he started writing his great *General Textbook of Entomology*, which he completed in 1925. He transferred to the Rothamsted Experimental Station, where he held the position of Chief Entomologist for the period 1918–31, returning in the latter year to Cambridge as Reader in Entomology.

Imms did much to encourage the study of entomology at university level. But towards the end of his life he established, with a single book and almost overnight, a reputation as a popular writer. This book, *Insect Natural History*, is one of the best that has so far appeared in Collins's New Naturalist series; on this book our reviewer commented: "If in years to come historians of Natural History in Britain find a sudden concentration of interest on the Phylum Insecta, dating from 1947, they will safely be able to lay the blame at the door of A. D. Imms."

The Bookshelf

Science in Films. Edited by Blodwen Lloyd. (London, Sampson, Low, Marston & Co., 1948; 210 pp. and 40 plates, 15*s*.).

A world review and reference book covering the principal advances of the scientific film during the last decade. Particularly interesting is the review of films and mathematics by I. R. Vesselo which mentions various attempts to improve on a mere animated rendering of conventional textbook theorems. Mr. R. A. Fairthorne, who is responsible for pioneer work in this field, has contributed a chapter on the film and scientific symbols. Medicine is covered by Dr. Brian Stanford in a review, and by Dr. Russell Reynolds in a brief account of cineradiographic technique. Recent advances in equipment are described by Derek Stewart, whose firm, Simpl Ltd., have specialised in high-speed cinematography.

The greater part of the book is taken up by the Reference Section which lists the official film organisation, makers, libraries and distributors in nearly all the countries of the world. There is also a comprehensive list of film titles, and an excellent index. As a reference work for all workers in the film industry, and particularly those interested in science teaching, this book can be recommended.

G. Parr.

The Genius of Industrial Research. By D. H. Killeffer. (New York, Reinhold, London, Chapman & Hall, 1948; 263 pp., 27*s*.).

Are scientific discoveries the product of genius? The work of a Newton or an Einstein would strongly suggest that they are. Fortunately, the march of science and technology does not depend solely on those flashes of genius which only a few times during its course light up a century. It rests to a large extent on those innumerable discoveries, inventions and improvements which are often born of accident as well as of years of planned and concerted effort, individual or collective. Most of the discoveries which account for the tremendous growth of our material civilisation in the course of the last fifty years are the result of 90% perspiration and only 10% inspiration—or luck.

It is this mixture which makes up the genius of industrial research, as is made clear by the numerous examples of discovery and invention instanced in this book. This is perhaps its most interesting feature. The reader will find described at length by the researchers themselves the methods which have produced or led to the development of new products or new industries, such as high-octane petrol, the gas-filled tungsten-filament electric lamp, celluloid, synthetic rubber, refrigerants, accelerators of rubber vulcanisation, synthetic aneurin chloride (vitamin B_1), the hardening of oils, etc. No one who reads the account of these discoveries can fail to realise that sheer hard work, skill, common sense and a little luck matter as much if not more in industrial research as what is commonly called genius. In contrast to pure research, which generally eludes fixed rules, industrial research can often be reduced to certain clear patterns.

The merit of the author is to have given an idea of what these patterns are.

The book will be particularly stimulating for those engaged in industrial research and those intending to devote themselves to it. It should also prove of value to the historian of science interested in the anatomy of discovery.

E. M. F.

Modern Glass Working and Laboratory Technique. By M. C. Nokes. (London, Heinemann, 1948, 3rd edn.; 153 pp., 7*s*. 6*d*.).

THIS book aims to be something more than the usual handbook on glass blowing and is extended to cover such subjects as metal-glass seals, photo-cells, vacuum technique, and the measurement of low pressures. As the author says, a greater measure of skill is required for the attainment of satisfactory results with glass than wood or metal, and for this reason the book will prove a useful adjunct to the student's laboratory training in technique and manipulation. The section dealing with glass working is up to date and includes information on resistance glasses and silica, and a particularly useful chapter is that on repair and construction of apparatus.

As an exercise, the construction of simple vacuum tubes and thermionic valves is described, and the photo-cells, although of the potassium type, should be adequate to demonstrate the principles of operation to the student who has the skill to make them.

The final chapters on diffusion pumps and vacuum gauges serve as a useful introduction to practical vacuum physics. The author does not, however, make clear the limitations of the diffusion pump, and the student may have the impression that this is all that is required for producing a high vacuum. A diagram of a complete pumping system would be helpful.

The book is well written and covers the subject very thoroughly. The many practical hints show that the author is familiar with the difficulties that the beginner encounters and has drawn on practical experience. The book should find a place in all school and college laboratories.

The Helicopter—or Anything a Horse Can do. By Colonel H. F. Gregory. (London, Allen & Unwin, 1949, 271 pp., 18*s*.).

THE number of men in the world who are qualified to fly helicopters is very small. One of them is Colonel H. Franklin Gregory, of the United States Air Force, who carried the world's first helicopter air mail, made the first helicopter landing on the deck of a moving ship, and set up helicopter height, distance and duration records. So, as Igor Sikorsky, the Russian-born aircraft designer, points out in a foreword, Colonel Gregory is "one of the best qualified to present a true picture of this interesting subject". It is a little disappointing, therefore, to find that the book, though extremely interesting, is rather more the story of Colonel Gregory's personal experiences in testing rotating-wing aircraft rather than a real history of the helicopter.

True the Colonel gives us some history. He covers briefly the early experiments by Sir George Cayley and Enrico Forlanini and others; the more practical work of Louis Breguet, the Frenchman who flew his own helicopter in 1907. He devotes several pages to the helicopter of George de Bothezat, another Russian exile, which flew in American in 1922. It is interesting to note that that aircraft, like so many of its modern successors, was seven months behind schedule on its first flight, which was made at only a few feet above the ground.

Colonel Gregory tells us a little of the great work of the Spaniard, Juan de la Cierva, about whom many chapters could be written. But only after 37 pages does the author reach the point where *his* story begins—when in 1936 he was selected to fly an autogiro.

From then onwards it is largely a story of helicopter development in the United States, with the accent on the Sikorsky types. Admittedly America has developed the helicopter and is making more use of it than any other country, and that the Sikorsky is among the best. British development is dismissed in three pages towards the end of the book, and takes us no farther than 1947. It is a pity, in view of the secondary title that it does not come up to date sufficiently to tell us about the Airhorse, the big helicopter made in this country by the Cierva company. All the same, anybody who is interested in flying, particularly in helicopters, should read the book.

J. S.

Technical Literature. By G. E. Williams. (London, Allen & Unwin, 1948; 112 pp. 7*s*. 6*d*.).

THE object of this book is set out in the preface; it is addressed to engineers and physicists to assist them in preparing technical and scientific papers for publication.

The author is well qualified to write on the subject of presentation of technical material as he is the editor of the *Journal of the Institution of Electrical Engineers* and has himself written a number of technical instruction books.

Although it is not a book on how to write English, two chapters are used to cover style, method of presentation, and choice of words. The remainder of the book deals with the preparation of the manuscript, the work of the sub-editor, and illustrations and their requirements.

The average technical man who wishes to put his work in a form suitable for publication has only a vague idea of the various processes through which it passes before appearing in print. A better knowledge of these will save him much time and trouble and give a bigger chance of having his work accepted. It is no part of an editor's work to rewrite the manuscripts of his contributors, and much promising material has to be rejected because it is in a form which is totally unsuitable for publication.

This book will prove a genuine help to authors and would-be authors, and should be bought by everyone who has to put his technical thoughts on paper.

Principles and Practice of Radar. By H. E. Penrose. (London, Newnes, 1949; 678 pp., 42*s*.).

THIS is intended to be a comprehensive textbook on radar, and thus includes sufficient elementary theory of radio to make the account of radar development coherent to the less-informed reader. It therefore includes short introductory sections on Ohm's law, resistance, reactance, and so on, which seems redundant to the radio engineer who wishes to learn about radar.

It is, of course, one of the difficulties of writing a textbook to decide where to draw the line between appeal to the novice and the knowledgeable, but where so many good elementary books on radio exist it would have been better to have concentrated on a thorough treatment of radar circuitary and assume a basic knowledge on the part of the reader. This is particularly the case here, where the elementary theory is so briefly presented that it is difficult to follow and in some cases the statements are inaccurate through over-condensation.

For example (p. 37) the delay switching in mercury vapour rectifiers is not required for the mercury to vaporise, but for the cathode to attain operating temperature. Also, the possibilities of suppressor-grid modulation did not lead to the introduction of multi-grid valves (p. 33)—exactly the reverse is meant.

When the author deals with radar he is on surer ground, although every so often a slip occurs (P.P.I. does not stand for 'prepared plan indicator', but Plan Position Indicator), and the chapters on radar aerials and switching are well done. The theory of transmission lines, waveguides, and cavity resonators is covered in three appendices, with some brief notes on test equipment.

A feature of the book is the exceedingly well-drawn diagrams, and a word of praise is due to the artist, who so seldom receives recognition. The whole book is nicely produced, and with revision of the text in some places, the second edition should prove a useful textbook for study of the subject.

G. PARR.

Between Pacific Tides. By Edward F. Ricketts and Jack Calvin. (Stanford University Press, Revised Edn. 1948. London, Geoffrey Cumberlege, Oxford University Press, pp. 365, 32*s*. 6*d*.).

IN Britain this book, which is an ecological study of some 500 common and conspicuous seashore invertebrates of the Pacific Coast between Alaska and northern Mexico, is likely to find its way chiefly into the hands of specialists. The exceptionally fine photographs reproduced in it should, however, interest a far wider readership, and we bring it to the attention of zoology teachers.

Printed and Published in Great Britain by Jarrold & Sons, Ltd., Norwich. *Editorial Offices: 244 High Holborn, W.C.1.*

Edward Turner,

an Englishman, was the first chemist to determine accurately the atomic weights of lead, chlorine, silver, barium, mercury and nitrogen — all substances of great scientific and industrial importance. The atomic weight of any element is the weight of an atom of it compared with that of one-sixteenth of an atom of oxygen. Accurate knowledge of atomic weights is invaluable. It enables analytical chemists to calculate the quantities of various elements present in a compound, chemical works' managers to forecast the probable yield of a manufacturing process, and metallurgists to assess the value of an ore.

Turner was born in Jamaica in 1796, but came to Scotland as a youth to read medicine at the University of Edinburgh, later proceeding to the Continent to study chemistry. Returning to Britain, he became a chemical lecturer at Edinburgh in 1824. Shortly afterwards he published his "Elements of Chemistry", which became one of the standard chemical text-books of the period. In 1828 he was appointed Professor of Chemistry at University College, London, but held this distinguished appointment for only a few years, as he died in 1837 just after reaching his fortieth birthday. In the eyes of his contemporaries, Turner was pre-eminently a great chemical teacher, but his more lasting reputation rests on his meticulous accuracy as an experimenter.

ICI

er,

first

ly the

lorine,

and

f great

rtance.

element

xygen.

alculate

forecast

an ore.

icine at

rning to

ublished

of the

London,